

with considerable iron in it; that of the lower 20 feet is of a bluish color, close, compact, much finer and more uniform in texture, and proves to be superior to the upper for building purposes. Only the outcrop has as yet been touched, and the ledge presents a broken appearance; but layers 10 feet in thickness are occasionally seen, indicating that as the quarry progresses in the hill the base will not be broken. The Mahoning sandstone is quarried at Derry station, Westmoreland county, on the Pennsylvania railroad, for ordinary building purposes; it is coarse in texture, with signs of stratification distinct, reddish-gray in color; it is used at Greensburgh and other places in Westmoreland county, and at McVeytown. The supply is obtained from large surface bowlders found along the west side of Chestnut Ridge mountain; in this part of the state large surface bowlders of the Mahoning sandstone are found and broken up to obtain material for ordinary building purposes. The stone splits readily into regular blocks, and is variegated in color by alternate different shades of a reddish color parallel with the stratification.

Near Derry station, on the Pennsylvania railroad, another ledge of sandstone belonging to the Upper Productive Coal Measures is quarried chiefly for the construction of coke-ovens by the Loyallhanna Coal and Coke Company. The stone is gray, massive, uniform, medium in texture, and unevenly bedded in courses varying in thickness from 2 or 3 inches to 3 feet. The total thickness of the ledge quarried is about 19 feet. Large, irregular, detached masses from 6 to 8 feet thick, heterogeneous in composition and useless for building purposes, are frequently found embedded in the other stones; these are locally called "nigger-heads". The blocks break up with rather irregular fracture, and the stone is not esteemed for any other purpose than the rough work required in the building of coke-ovens, and as these ovens are lined with fire-brick the stone is not subjected to any great degree of heat. The quarry is situated at the foot and on the west side of the anticlinal axis known as Chestnut ridge; and there is considerable dip of the strata toward the northwest, away from the crest of the mountain.

At Greensburgh the sandstone of the Upper Productive Coal-Measure series is quarried to a limited extent for cellar and foundation stone used locally. It is gray, irregularly stratified, of medium texture, and unevenly bedded. The total thickness of the ledge quarried thus far is 15 feet, though in sinking a well close by the whole thickness of the ledge was found to be 37 feet. The layers as observed in the quarry vary from 3 inches to 2 feet in thickness, and a thin vein of coal lies beneath the ledge of stone.

In Webster, near the Monongahela river, in Westmoreland county, a sandstone of the Upper Productive Coal Measures is quarried for paving and used in Pittsburgh. It is gray in color, fine in texture, evenly and distinctly stratified, evenly bedded, and in courses varying from 3 to 16 inches.

At Scottdale, Westmoreland county, on the Southwest Pennsylvania railroad, the sandstone of the Upper Productive Coal-Measure series is quarried for the construction of coke-ovens and house foundations locally. It is of a brownish color, regularly stratified, and evenly bedded in courses varying in thickness from 2 to 8 inches. The total thickness of the ledge of the quarry is  $4\frac{1}{2}$  feet, which thickness seems to continue regularly throughout. From the hardness of this stone and the ease with which it may be taken out for flagging, it seems better adapted to this purpose than to any other.

At Layton station, Fayette county, on the Baltimore and Ohio railroad, there is a sandstone (between the Upper and Lower Productive Coal Measures) of the Lower Barren Measures quarried and crushed into sand for the manufacture of glass; it has, however, occasionally been used for building purposes. The abutments of the suspension bridge across the Youghiogheny river at Connellsville, and those of the Saint Clair Street bridge at Pittsburgh, were constructed of this stone. It is light gray in color, of coarse texture, irregularly stratified, evenly bedded, and lies in two courses of 10 feet each in thickness, making the total thickness of the ledge 20 feet. The stone increases somewhat in hardness from top to bottom. This material seems very well adapted to all ordinary building purposes, but it serves so well for glass-sand that so far it has been found more profitable to quarry it for that purpose.

Three miles southeast of Connellsville, Fayette county, on the Baltimore and Ohio railroad, is a sandstone of the Lower Productive Coal Measures also quarried for glass-sand. It very much resembles the material at Layton station, and is of such quality that it might be used for local building purposes. It is easily dressed, and exposures of the ledge which have not been disturbed artificially seem to indicate that the stone is durable. There is no regular division here into layers, the rock being usually found in one mass. The quarry is located on the side of the mountain, and the dip of the stratum is about 15 degrees at the point where quarried.

In Connellsville, in the same county, the sandstone of the Barren Measures is quarried for ordinary building purposes and used locally. It is gray, coarse in texture, indistinctly stratified, and evenly bedded in courses varying in thickness from 2 to 3 inches at the top to 12 feet at the bottom of the ledge, the total thickness being about 40 feet. The material of the uppermost 30 feet is of a light brown color, and appears to have a little clay in its composition; it cracks under the effect of water-soaking and freezing, is soft when first quarried, but hardens considerably on exposure. The stone breaks or splits rather easily in almost any direction; wears away rapidly under foot-wear, but seems very well adapted for use in caps, sills, and other trimmings. The color of the lower 8 feet of the ledge is bluish, and the material is variable in texture, full of nodules of iron, and holds a good many fossil coal-plants.

Three miles southeast of Uniontown, on the side of the Chestnut Ridge mountain, surface rocks of Mahoning sandstone are found and broken up for ordinary building purposes, used chiefly at Uniontown. The material is gray, coarse in texture, with signs of irregular stratification. The blocks are sometimes as large as 30 by 20 feet

and 12 feet in thickness. When the large rocks are first broken the material is comparatively soft and easily worked; but it becomes hard on exposure to the air, and small fragments that have been long exposed to the atmosphere are extremely hard. This stone seen in houses in Uniontown built fifty or sixty years ago exhibits every evidence of durability.

Near Waynesburgh, Greene county, sandstone of the Upper Barren (above the Upper Productive Coal) Measures is quarried to a limited extent for building purposes and for bases of monuments and other cemetery work, used locally; it is gray, massive, and coarse in texture. Thus far only large surface rocks, some of them 30 feet square and 5 feet in thickness, have been quarried. There seems to be no exposure showing a ledge in place; some of the rocks are on top of the hills. It is uniform in color and texture, works well, may be split horizontally and vertically, and takes carving well for a stone of coarse texture, as raised lettering is sometimes worked on monuments of this material; it stands exposure, becoming harder after leaving the quarry.

Near West Union, Greene county, on the Waynesburgh and Washington road, sandstone of the Upper Barren Measures is quarried for caps, sills, trimmings, and for ordinary building purposes and cemetery work. It is used at Waynesburgh, and the stone-work in the college building at that place is of this material. It is gray in color, massive, of coarse texture, and is obtained by breaking up surface rocks, which are from 10 to 20 feet square and 5 or 6 feet in thickness. These rocks where exposed are covered with a thin, cement-like crust, on which grows a grayish moss. When the crust is broken the stone beneath is found not to be discolored by weather.

Five miles west of Washington court-house, Washington county, on the Baltimore and Ohio railroad, sandstone of the Upper Barren Measures is quarried for caps, sills, curbs, steps, and other building purposes, and used locally. It is gray, coarse in texture, with signs of irregular stratification; the stratum is 20 feet thick, and solid, there being no division in the courses and few joints. The stone-work in the Washington and Jefferson College building at Washington, Pennsylvania, and that in the town hall at the same place, are of this material. The texture and appearance of this stone are uniform throughout the ledge, and the material is among the best found in the vicinity, though the supply of good building stone in this section of the state does not seem to be either abundant or widely distributed.

On the Pittsburgh and Southern railroad, 3 miles east of Washington, Pennsylvania, and on the National pike, about a mile east of that place, there are quarries of sandstone of the Upper Barren Measures, quarried chiefly for foundation stones, caps, sills, and other ordinary building purposes, and used locally. The foundation of Le Moyne's crematory is of this stone. It is gray, coarse in texture, with signs of irregular stratification, uneven bedding, and in courses from 1 foot to 6 feet in thickness, the thin layers often intervening between thicker ones; and in blasting, the thick layers often divide into four or five thin ones.

Near the Pittsburgh, Cincinnati, and Saint Louis railroad, 1½ miles north of Canonsburg, Washington county, sandstone, locally called freestone, of the Upper Barren Measures, is quarried for paving and hearth stones; used also for sills in Washington, Mansfield Valley, and Pittsburgh, Pennsylvania. The stone-work of the Pennsylvania Reform School building, in Washington county, is of this material. It is gray, uniform, of medium fine texture, evenly and distinctly stratified, and evenly bedded. The total thickness of the ledge in this quarry is about 6 feet; the top layer varies from 8 to 20 inches in thickness, then follow two or three layers each about 2 inches, and next the bottom are layers from 8 to 12 inches in thickness, with thinner ones intervening. The bedding is exceedingly even and regular, the surface of the layers being as smooth as if sawed. For paving and hearth stones no dressing is needed except at the edges. The stone splits straight in the direction of the lamination, and vertically, but is hard to dress. It is a favorite in this region for paving and hearth stones.

Near Monongahela City, Washington county, sandstone of the Upper Productive Coal Measures is quarried for ordinary building purposes, and is used chiefly in Pittsburgh and neighboring cities, and in the construction of the Monongahela bridge, Washington county. It is transported by rail and by boat. It is gray, coarse in texture, massive, evenly bedded in courses from 4 to 6 feet thick, and has a good local reputation.

On the Ohio river and the Pittsburgh and Lake Erie railroad, at Stoop's ferry, Allegheny county, the United States government quarries sandstone of the Lower Barren Measures for building purposes, to be used chiefly at Pittsburgh, and to some extent in the construction of bridges at Rochester and Davis Island dam. Transportation is by boat. It is gray, of medium fine texture, massive, evenly bedded, and in thick layers. This quarry has been opened for many years, and worked in a small way, but never to any great extent until the building of the Pittsburgh and Lake Erie railroad, many of the bridge abutments and culverts of which are built of this stone. A house standing near this quarry at Stoop's ferry, built of this stone forty-two years ago, is still in a good state of preservation.

At Walker's mills, on the Cairo and Saint Louis railroad, 12 miles west of Pittsburgh, Allegheny county, sandstone of the Lower Barren Measures is quarried for railroad-bridge masonry, and used on the divisions of the Pittsburgh, Cincinnati and Saint Louis railroad between Pittsburgh and Columbus, and also on the branches running from Pittsburgh to Washington, Pennsylvania, and Wheeling, West Virginia; it is gray, of medium fine texture, irregularly stratified, and unevenly bedded in courses varying in thickness from 18 inches to 5 feet, except the bottom layer, which is in places 18 feet in thickness; none of them, however, are of a uniform thickness throughout, but vary considerably within short distances. Partings of shale from a few inches to over a foot in thickness often intervene

between the layers of stone. The lower part of the bottom layer is full of nodules of peroxide of iron, often weighing several pounds each. Coal-plants, known as calamites, are found in the lower portion of the ledge. These quarries are situated on the same ledge (the Morgantown sandstone of the *Second Geological Survey of Pennsylvania*), as the local quarries in the vicinity of Pittsburgh and Allegheny, and the character and appearance of the stone are the same as those of the stone quarried at the latter place. The total thickness of the ledge is about 80 feet, setting in thicker as the quarries progress in the hill. A thickness of about 30 feet at the top is of a thin, shelly, broken character, suitable for railroad ballast, for which it is extensively used by the Pittsburgh, Cincinnati, and Saint Louis railroad. Beneath this there are 50 feet or more of solid stone, lying in regular layers varying in thickness from 18 inches to 5 feet, except the bottom layer, which is in places 18 feet thick. This sandstone, as well as nearly all of the sandstones in the region immediately surrounding Pittsburgh, has some calcareous matter in its composition, and wherever a face of the ledge of stone has been exposed for a long time it is very much honey-combed into fantastic shapes, apparently by the disappearance of this calcareous matter, leaving the more siliceous portions intact. The stone when first quarried is very sensitive to the action of frost, and quarrymen say it is best to get it out long enough before winter to allow the "sap" to dry out.

At Mansfield Valley, Allegheny county, also on the Pittsburgh, Cincinnati, and Saint Louis railroad, Morgantown sandstone (near the top of the Lower Barren Measures) is quarried for bridge masonry, and its character is the same as that of the stone from the other quarries on the formation in this region.

The Morgantown sandstone is quarried quite extensively in the hills within and near the limits of Pittsburgh and Allegheny, and it is used almost exclusively for cellars, foundations, sewers, and other underground work in those cities and vicinity. While its character is such as to exclude it from other building purposes, it seems to answer quite well for underground work, and supplies nearly all the stone used in the cities named for this class of construction. It is a bluish-gray in color, medium to fine in texture, with signs of irregular stratification, the bedding moderately even, in layers varying in thickness from a few inches at the top to 4 or 5 feet at the bottom of the ledge. Thin partings of shale sometimes rest between the thin layers at the top, especially at the outcrop. The usual thickness of the ledge is about 35 feet, though at Wood's Run quarry and other places in the neighborhood it reaches a thickness of 100 feet. There is considerable calcareous matter in this stone, and in such a form as to make it liable to decomposition, especially in the smoky and acid atmosphere of Pittsburgh, and at present the inspector of buildings forbids its use for any purpose of construction except underground work. It was, however, frequently used in the construction of important buildings at Pittsburgh; the court-house was built of it, and the stone in its walls is decomposing so rapidly that it is probable that within a few years a new building must be provided. The material when first quarried presents a substantial appearance, and it was formerly thought that the immense cliffs of it which were projecting out of the hills everywhere in the vicinity would furnish an inexhaustible supply of building stone of superior quality for all purposes of construction, and many important buildings were constructed of it before the error was discovered.

At Baden, situated on the Pittsburgh, Fort Wayne, and Chicago railroad and on the Ohio river, in Beaver county, sandstone of the Lower Barren Measures is quarried for foundations and other ordinary building purposes, and is used in Pittsburgh, Brownsville, Greensburgh, and vicinity. It was used in the construction of the post-office at Pittsburgh. It is gray, massive, coarse in texture, evenly bedded, in three courses, 8 inches, 8 feet, and 7 feet, respectively, and is considerably broken by irregular joints. It was operated for the two years expiring in August, 1880, by the United States government for stone used in the construction of Davis Island dam.

At Kiasola station, on the Pittsburgh and Lake Erie railroad, in Beaver county, sandstone of the Lower Productive Coal Measures is quarried for ordinary building purposes, and is used in Pittsburgh. The bridge masonry and canal locks in the vicinity are constructed of this material. It is gray in color, of coarse texture, massive, and evenly bedded in thick courses.

Near Beaver Falls, Beaver county, on the Pittsburgh, Fort Wayne, and Chicago railroad, 30 miles northwest of Pittsburgh, sandstone of the Lower Productive Coal Measures is quarried for steps, fronts, curbstones, trimmings, monuments and other cemetery work, fences and walls, and is used in Pittsburgh and vicinity. It was used in the construction of Hostetter's stone front on Fourth avenue, Pittsburgh, and in important buildings in that city. It is gray in color, rather coarse in texture, with signs of irregular stratification, is evenly bedded in layers varying from 6 inches to 5 feet in thickness, with thin shale sometimes between. This is a strong and durable stone, and surface blocks which have slipped from the ledge, and which have been exposed for ages, indicate that it stands exposure well. The quarry is on the crest of a hill 300 feet above the Big Beaver, which flows half a mile from its base and discharges into the Ohio 5 miles distant. The following is a slight description of a section of this quarry: The top layer is a material of uniform color, red when quarried, taking its color from the red iron ore immediately overlying the quarry. A thin bed of shale intervening between each two strata facilitates the working of the rock; between the first and second layers are some thin beds varying from 6 inches to a foot in thickness. No. 2 is a very fine, close-grained, white stone, occasionally of a buff or straw color. It is reported to be the best in the quarry, and ranks well with the different stones used in Pittsburgh for building or cemetery purposes. The supply from this bed is not sufficient for the demand. No. 3 is a hard, heavy, fine stone, always brown in color, except along the cleavage, where it is white. No. 4 is usually a straw or buff color, strong and fine in texture. No. 5 is softest,

sawing well, and variegated in color so as to be objectionable for rubble work; intervening is a thin bed of shale of bluish color, under which lies No. 6, resting on a coal bed. No. 6 is blue in color, except the sap coloring, which is buff, penetrating from 1 foot to 2 feet. Nos. 5 and 6 sometimes come together, forming one course. Nos. 3 and 4 sometimes contain "nigger-heads" weighing occasionally from 10 to 20 tons. They are blasted out and thrown over the dump. The lower (No. 6) contains fossil coal-plants; in the other rocks the fossils are silicified. Between Nos. 1 and 2 there are fossils of *stigmaria* quite perfect and entire, and the joints are frequently filled with stalactites. There is a slight dip from northwest to southeast.

At Homewood, Beaver county, sandstone of the Lower Productive Coal Measures is quarried for ordinary building purposes and bridge construction, and is used chiefly at Pittsburgh. It varies from a gray to a brown in color, is coarse in texture, shows signs of irregular stratification, and is unevenly bedded in thick courses; it ranks among the best building stones in the western part of Pennsylvania.

Near Wampum, Lawrence county, Homewood conglomerate of the Lower Productive Coal Measures is quarried for bridge construction on the Pittsburgh and Lake Erie railroad. It is gray in color, coarse in texture, massive, evenly bedded, and in thick courses. The Homewood sandstone, which is the upper stratum of the Conglomerate Measures, furnishes most of the building stone quarried in Lawrence county. It is usually a coarse-grained, white or grayish-white sandstone, but in some localities it is colored brownish-red by peroxide of iron. Other strata, especially the Conoquenessing sandstone, are quarried now and then to some extent in different localities. The quarries near Wampum are operated by stone-work contractors on different lines of railroad passing through the place.

At Sharon, Mercer county, the Homewood sandstone of the Lower Productive Coal Measures is quarried for bridge construction and foundations; it is gray, massive, and unevenly bedded in layers not usually exceeding 3 feet in thickness. Several members of the group near the lower limits of the Carboniferous rocks, known in the *Second Geological Survey of Pennsylvania* as the Conglomerate Measures, crop out in the vicinity of Sharon. Different strata of sandstone in this series, and the Chenango sandstone in the Lower Conglomerate, have been quarried for building stone in this locality, but none of superior quality has been produced. The stone from the quarries now operated is a hard, coarse-grained sandstone that is seldom dressed; it seems to be quite durable, however, and is perhaps the most economical material to be obtained in Sharon for cellar walls and foundations, and blocks as large as are ordinarily desired for bridge work can be obtained in some of the quarries. Since the Erie and Pittsburgh canal was abandoned its stone locks have furnished a large amount of cheap and usually quite good building stone to the section of country through which the canal passed, and particularly from Newcastle north. Some of the quarries from which stone for these locks was obtained have been worked but little since the building of the locks, though when the supply from these is exhausted some of the quarries will doubtless be worked again. Sandstone can be obtained almost everywhere in Mercer county, but it is not all good building stone; the localities that do furnish good building stone are but a few miles apart. About 40,000 cubic feet of stone have been quarried for the foundation of the new county infirmary at Mercer. The rock was obtained from quarries located within a radius of 4 miles surrounding the town. The Sharon conglomerate is quarried near Greenville and Chenango, in Mercer county, for flagging, and is used locally. It is gray, fine in texture, has signs of even and distinct stratification, and is evenly bedded in layers usually not exceeding 8 inches in thickness. This formation has here a peculiar development; the stratum is about 12 feet in thickness, and not solid as usual, but in courses from 1 inch to 9 and sometimes 12 inches in thickness. The rock is a blue, fine-grained sandstone; in some places where it has been thoroughly drained, and the particles of iron have been thoroughly oxidized, it has a gray or buff color; it is an excellent paving material, and is shipped to various points in western Pennsylvania and eastern Ohio for paving sidewalks, and is used almost exclusively for this purpose in the town of Greenville in the first-named state. Sometimes the heavier courses occur in the upper portion of the stratum; the iron in them has been peroxidized, and the stone is used to quite an extent for lintels and water-tables. The natural blocks are seldom rectangular, and there is considerable material broken off in shaping up the blocks. Most of this stone, however, finds a ready sale for building foundations.

At Stoneboro', Mercer county, the Homewood sandstone (top member of the Pottsville conglomerate) is quarried for foundation and bridge construction. It is gray and light brown in color, coarse in texture, massive, unevenly bedded in layers from 1 foot to 4 feet in thickness, and is used chiefly in the vicinity. The stratum of quarry rock is about 20 feet in thickness; it is very much fissured, and the natural blocks are variously shaped, though easily reduced to any required form.

At Rockwood, near Oil City, Venango county, detached blocks of the Conoquenessing sandstone (the middle member of the Pottsville conglomerate) are quarried for bridge construction. The stone is gray, coarse in texture, massive, evenly bedded, and in thick layers where found in place. In Report 2<sup>d</sup>, *Second Geological Survey of Pennsylvania*, p. 57, Professor White describes a honey-comb rock found in Crawford county, and near Franklin, in Venango county, and thinks the blocks found in these different localities have come from the same bed, possibly the Conoquenessing sandstone. Some of the blocks at Rockwood show that the lower portion of the stratum from which they were detached has the same peculiar structure, and is probably the same bed.

At Garland, Warren county, detached blocks of the Sharon conglomerate (bottom member of the Pottsville conglomerate) are quarried for bridge construction in the vicinity, and on the Pennsylvania and Erie railroad.

The stone is gray, coarse in texture, massive, evenly bedded, and in thick courses where found in place. The principal quarries are located about 400 feet above the level of the Pennsylvania and Erie railroad. The stone is lowered from the quarry to the railroad on a small car running on an inclined track; two cars are used, connected by a cable passing around a drum. The stratum from which the blocks are quarried, as detached, caps the hill about 100 feet above the level of the quarry. The blocks referred to vary in size from the smallest to blocks containing several thousand cubic yards. Most of the building stone that has been used in this part of western Pennsylvania was obtained from such blocks, and from long exposure the material from them is almost universally very hard and difficult to dress; but since it can be obtained without stripping, it is cheaper on the whole than the softer material which might be obtained by stripping the stratum from which the blocks are detached. It is also less expensive, because, the blocks being already detached, a part of the usual work of quarrying is saved. It is difficult, however, to obtain a large amount of this kind of stone of uniform color; a more uniform stone can usually be obtained from the undisturbed stratum. This variegated coloring is due probably to the unequal effects of exposure on different portions of the surface blocks in the oxidizing of the iron in the composition of the stone, and to the unequal effects of exposure on other ingredients of the rock.

Other localities worthy of special notice where building stone has been obtained in this vicinity are near Sinnamahoning, in the southeastern part of Cameron county, and near Ridgway, in the western part of Elk county. The amount of capital invested is small, considering the real extent of the business in this part of the state. Most of the stone quarried is taken out by builders and contractors, and is used chiefly for foundations and bridge construction, the only considerations being cheapness and durability. Detached blocks are found almost everywhere in the ridge except in Erie county. As these detached blocks have been exposed to atmospheric action for ages it is seen at a glance whether the material is durable; and if it splits well it is quarried, and is used in localities to which it can be most conveniently transported. The sum paid for the privilege of quarrying is seldom more than 10 cents per cubic yard for any amount.

Near Meadville, Crawford county, the Sharon conglomerate is quarried for general building purposes and is used locally. It is a light gray, coarse sandstone, massive, evenly bedded, and in thick courses. The stratum is about 45 feet in thickness, though only from 20 to 30 feet of the upper portion is suitable for building stone; the lower portion is coarse, and sometimes a mere mass of quartz pebbles. The upper portion or quarry rock is quite uniform in texture; it is light gray in color, is easily broken into rectangular blocks by means of wedges; is soft when first quarried, easily dressed, and is quite strong and durable. The quarries are located in the summit of the hill, about a mile and a half northeast of Meadville, and the highway is down-grade all the way to the town. Quarries have been worked in other localities in the vicinity, producing an equally good building stone, but from none of these localities can the material be transported readily to Meadville. The Chenango sandstone, here a brownish-gray stone, containing numerous concretions of peroxide of iron, might be quarried to an unlimited extent near by. It has been quarried to some extent and used in some of the finest buildings in Meadville.

**QUARTZ PORPHYRY.**—Mr. A. E. Lehman, Second Pennsylvania geological survey, sent a number of specimens of quartz porphyry from near Fairfield and Graefenburg, Adams county, and from Pine Grove and Laurel Forge, in Cumberland county. These rocks are identified by Dr. T. Sterry Hunt with the orthopelsite porphyries of the Huronian system of Canada; they underlie the Potsdam sandstone of the South mountains, and overlie the Philadelphia gneiss. They are of a purple color, usually indistinctly stratified, and regularly bedded in courses of varying thickness. The structure of the rock is a fine, compact matrix, with distinct crystals disseminated through it; it is well adapted to ornamental work, as it is rich in color, durable, and susceptible of a good polish, and in many places could be obtained in abundant quantities. It has not as yet been quarried for purposes of construction.

#### SLATE.

The slates of Pennsylvania are used for school slates, for roofing, for mantels, and for flagging, both in foreign countries and in the principal cities of the United States, especially from New York westward. The quarries of roofing slate at East Bangor, Pen Argyl, and near the Wind Gap in Kittanning mountain; at Chapman, in Northampton county, Slatington, Lehigh county; and in fact all the slate quarries in Northampton and Lehigh counties are located on strata of Hudson River age, overlying thin beds of Utica shale, which in turn rest on the Trenton, Chazy, and Calcareous limestones (the magnesian limestone of the great valley, Siluro-Cambrian).

The Hudson River slate formation, 5,000 feet thick more or less, makes two-thirds of the floor of the great Lebanon, Cumberland, or Shenandoah valley, as it is variously called in the states through which it extends, the valley being bounded on the north and west by the Blue mountain, and on the south and east by the South mountain. The Hudson River slate formation occupies the valley from its middle line northward and westward to and up the slope of the North mountain, while the Trenton and magnesian limestones occupy the southern and eastern side of the valley to the foot of the South mountain.

The roofing-slate belt is a continuous strip of varying width extending through Lehigh and Northampton counties close to the foot of and parallel with the Blue mountain. It is not, however, of such a character at all points on the formation as to be suitable for roofing slate. The localities where the material is of such character as to be suitable for the purpose are carefully selected. In fact, the roofing-slate quality is characteristic only of certain beds or small groups of beds at various geographical horizons in the great Hudson River slate formation.



From Report D D D of the *Second Geological Survey of Pennsylvania*, which is soon to go to press, and the revise file of which was kindly loaned for use in this report by Professor J. P. Lesley, state geologist of Pennsylvania, we learn that the whole slate belt referred to as Hudson River slate is an irregular hill country, strongly contrasting with the magnesian limestone country, which borders on the south, both in the comparative number and ruggedness of its water-courses; and that with the exception of Schoharie ridge, in Lehigh county, and perhaps Sandstone ridge, north of Hockendaugua, there are no well-defined ridges marking the outcrops of harder subdivisions of the great slate formation, so that it is difficult to separate the main belt into subordinate belts. The whole mass is one formation equivalent to the Hudson River slate of the *New York Geological Survey*, excepting that along the southern border Mr. Prime reports occasional traces of Utica black slate immediately overlying the Trenton limestone. The southern border of the slate district is everywhere a one-sided hill or steep descent toward the limestone lands. The whole formation is divisible into an upper and lower mass, the upper being more massively bedded, and therefore supporting more elevated country. Its uppermost beds constitute the southern slope of the Blue mountain, but the large and important roofing-slate quarries are all in the lower subdivision of the formation.

It is further stated that these same slates extend along the north side of the valley, through Berks, Lebanon, Dauphin, Cumberland, and Franklin counties, into Maryland and Virginia. There are no slate quarries open west of the Schuylkill on this formation, but the same slate formation goes on across the state, and the cleavage shown by the outcrops has about the same appearance.

Red slate outcrops through the western part of Berks county, and a careful examination may disclose that some of the outcrops will produce suitable roofing material.

In New Jersey, at the Delaware Water Gap, a thickness of 3,000 feet is assigned to the whole mass. Mr. Prime's measurements along the west bank of the river make it more than 5,000 feet. Mr. Chance's independent measurement at the Water Gap places the roofing-slate quarries at 2,350 feet respectively beneath the Oneida conglomerate, and his estimate of the whole thickness of the Hudson River slate formation is about the same as Mr. Prime's. In Berks and Lebanon counties the total thickness is stated at 6,000 feet.

The following is an approximate estimate of the position of the quarries on the formation, beginning with the highest and going down: First, quarries at Pen Argyl; second, Hindbeek quarries; third, Slatedale; fourth, Steinvillie; fifth, Slatington; sixth, Bangor.

The "ribbons" in the slate, described by Professor H. D. Rogers, are very thin layers, from a few lines to an inch or two in thickness, traversing the rocks in bands parallel to each other and at various distances, not generally exceeding 2 feet. These ribbons indicate the direction of the dip of the strata, being seams of somewhat different composition from the rest of the mass. Between each two of the ribbons the layer of slate is homogeneous or of uniform texture and composition, but a difference in the quality of the slate on the two sides of one of these thin layers is quite common. When we examine a new surface of the slate, the usual and permanent color of which is dark bluish-gray, the hue of these ribbons is nearly black, but on exposure to the atmosphere they show, after some time, signs of spontaneous decomposition, and display a whitish efflorescence which indicates that this part of the slate contains sulphuret of iron. The ribbons are therefore carefully excluded from the slate when the latter undergoes the operations of cleavage and trimming in preparation for the market. In most of the slate quarries near Bangor, Northampton county, which is the northern end of the slate belt, the slate is tough and possessed of some flexibility, cleaving readily, the proportion of waste being comparatively small. Toward the southern end of the slate district of Lehigh and Northampton counties the texture and quality of the slates are slightly different from those in Northampton county, and a greater proportion is manufactured into school slates, and some is also shipped for sidewalk paving. Most of the large quarries in this district are producing on an average twice the amount of slate produced two or three years back, with but one-third more force of men and machinery, showing that within certain limits a large force is more economical than a small one. This is true of the quarries at Pen Argyl, East Bangor, Slatington, and in fact of the whole district. From 1876 to 1880, the foreign demand was so great that but little attention was paid to home trade, there being in fact scarcely any home trade. Slates were so low in price that foreign merchants could purchase here and ship to England cheaper than they could buy at home; at present the increase in price of slates created by the home demand has stopped shipments to foreign countries altogether.

In Report D D D, *Second Geological Survey of Pennsylvania*, there is a chapter on the slate region of Northampton and Lehigh counties, covering all that part of the great Lebanon and Cumberland valley which lies between the Delaware and the Schuylkill rivers, and between the Blue or Kittatinny mountain on the north and the edge of the limestone on the south; and there are notes describing the individual quarries. We are indebted to this report for some of the measurements and descriptive matter in the following remarks concerning some of the quarries which were in operation during 1880. The details given will aid in obtaining definite ideas as to the quarries themselves and as to the structure of the slate.

The Bangor Union Slate Company's quarry is 250 by 130 feet deep at the deepest place, with from 10 to 20 feet of drift on the surface. The largest bed is 4 feet thick. The synclinal axis which shows in the Bangor quarry also shows in this one, but the plane of the axis dips slightly to the south instead of to the north as in the Bangor. The

quarry is worked by five cable derricks, which supply the material to twenty shanties, *i. e.*, the sheds in which the slate is cut into shape for roofing. The derricks are run by an engine which, working a line of shafts, connects with the cable derricks by conical friction-wheels.

Bry & Short's quarry, 300 yards east of the old Bangor quarry, is 200 by 150 by 60 feet, with a dip of 10 feet north; the cleavage is 20° south, and the largest bed is 4 feet thick. The quarry is worked by cable derricks run by steam-power. The school slates are planed at the quarry.

The Star quarry, 500 feet west of the east Bangor No. 2, is 200 by 200 by 50 feet, and the cleavage is 20° south; it is worked by cable derricks run by steam, and there are also horse-power derricks, beside appliances for cutting roofing slate and circular saws for cutting school slates. The ribbons in this and the other quarries usually indicate the direction of the stratification, which in this slate district is usually not parallel with the cleavage, but crossing it at varying angles. Much of the material is quarried in such shape that it may be worked up for ornamental purposes instead of being split into roofing slates.

In the Bangor Slate Company's quarry there is a synclinal axis passing through the center of it about 70 feet below the surface; the cleavage and the plane of the axis dip 5° to the north. There are 30 feet of drift on the top of the quarry. The largest bed is 9 feet 6 inches thick. The synclinal axis, being the same that shows in the Washington quarry and in the Bangor Union, pitches to the west. The hoisting is done by cable derricks run by steam, but horses and carts are also used.

The north Bangor quarry No. 1 is 200 by 200 by 40 feet at the deepest place. There are 20 feet of drift covering the slate, and 1 foot below the drift the material is of such quality that it serves for roofing slate. Cleavage, 10° south and 30° east; dip, 45° south and 30° east. The two largest beds are 4 feet thick, and there is a bed measuring 10 feet along the cleavage. The series of beds extends all the way across the flooring of the quarry and all of them are under 4 feet each in thickness.

The north Bangor quarry No. 2 is a few hundred feet north of No. 1, and is 150 by 100 by 40 feet deep. The dip is 35° south and 30° east; the cleavage is 15° south and 30° east. The beds that are exposed are mostly small, each under 4 feet in thickness.

Jackson quarry is 300 by 200 by 100 feet deep. It is worked by cable derricks run by double cylinder steam-engines. The slates come out in good-sized blocks, some of them 20 feet long.

The Jory quarry is 400 by 200 by 80 feet deep. It is worked in the center of a synclinal axis; the dip of the rocks is slight in the center of the axis; the plane of the axis is vertical, while the cleavage is horizontal. This is the only quarry in which the cleavage can be seen at right angles or at any considerable angle to the plane of the axis. The beds worked are not large, but the cleavage makes such a slight angle with the bedding that large blocks can be taken out.

The west Bangor quarry at Pen Argyl is 125 by 150 by 40 feet deep. The dimensions of the largest slab quarried were 13 feet long by 4 feet wide by 18 inches thick, but slabs 15 by 6 feet by 12 inches thick might be obtained.

Stephen Jackson & Co.'s quarry is 400 by 200 by 80 feet deep; dip, 28° south; cleavage, horizontal; beds from 12 to 25 feet long along the cleavage.

The Chapman quarry is 500 by 300 by 130 feet deep. Cable derricks run by steam are used in hoisting the slabs out of the quarry preparatory to working them into roofing slates. Splitters here make from two to six squares a day, averaging about four. The hoisting apparatus is very complete; a slab weighing 2 tons is hoisted 150 feet vertically and 300 feet horizontally in about two minutes. There is a factory here for making and planing slabs and other sawed material, the appliances consisting of diamond saws, planers, gig-saws, and smoothing table—the diamond saw, by reciprocating motion, cutting through slate at the rate of an inch in five minutes, making about 50 strokes a minute. The slates are all thinly-bedded, split well, and are tough. The blocks come out of the quarry in large, even pieces, some of them 20 feet long. The usual dimensions are 8 by 10 feet or less.

Frederick Prime, jr., in Report D D, *Second Geological Survey of Pennsylvania*, says substantially of the slates toward the southern end of this slate quarry district, in Lehigh county, at Slatington, White Hall, Slatedale, Lynnport, and Steinvile, that they are distinguished by bluish-gray or black color, cleave readily into thin slabs, and when the cleavage forms a high angle to the bedding and the slates are free from grit and are otherwise of good quality, they are quarried and are excellently adapted for roofing purposes, school slates, blackboards, and other articles of this nature. Owing to the property they possess of cleaving readily the slates are usually observed with the cleavage predominating to such an extent as to obscure and often to entirely conceal their stratification. As a rule their true bedding can only be observed by means of the wavy lines of a slightly different color from the body of the slates, which are constant and persistent in their passage through the cleavage, these lines indicating the stratification. The quarries of the Lehigh and Northampton district in Pennsylvania are distant about 100 miles from the city of New York and 75 miles from Philadelphia. In 1875, according to Professor Silliman, but five quarries were worked in Lehigh county—the Washington, the Franklin, the Trout Brook, the Bangor, and the Douglas.

The North Peach Bottom Slate Company's quarry is in Whitehall township, on the Lehigh Valley railroad, east of Bethlehem. The largest slab which has been moved thus far was 42 by 10 feet by 20 inches thick, and

blocks 40 by 20 feet by 20 inches thick might be loosened. The custom is to reduce the blocks to such size that they may be conveniently hoisted out of the quarry. The form of the natural slabs here is rhomboidal. The slates come out remarkably even and straight; they are 16 feet long, a straight edge touching at nearly every point on a slab of the material. Transportation from the quarry is afforded by means of the Lehigh Valley railroad and Lehigh and Delaware canal. There is but one grade of material quarried, it being all similar in structure and texture. It is reported that roofing slates from this quarry exposed for thirty years are not yet discolored and need no repairs. The slate is sawed, planed, and rubbed by steam-power. The method of draining the quarry is by a siphon consisting of a pipe  $1\frac{1}{2}$  inches in diameter and 450 feet long. Mr. John Crump, of the North Peach Bottom Slate Company, states that in his examination of the slates in Pennsylvania and Vermont, and those of Wales, in Great Britain, and of the Angiers district on the Loire, France, he found that the material from this quarry ranks very high in respect to size, thickness, and evenness of the slabs that may be quarried and the hardness, toughness, and uniformity of texture of the material, and for its freedom from ribbon or spots, stains, or quartz veins. The dip of the cleavage in this quarry is about  $50^{\circ}$  northeast to southwest. The main joints are about 50 feet apart, and about 35 feet below the surface soil sound slate commences half an inch thick, increasing in thickness of strata as it descends. At about 45 feet below the surface the beds are 6 inches thick; at 60 feet, 12 inches thick, and at 80 feet, 20 inches thick. This is the greatest depth quarried thus far, and the proprietors believe that the beds will go on increasing in thickness at a like rate to a depth of 200 feet, at which depth they expect a deterioration.

The color of the slate is blue-black. This slate has been much used by the United States government at Albany, New York; New York city; Topeka, Kansas; Austin, Texas, and Saint Louis, Missouri. The Patent Office building at Washington city has tiling on the top floor of the north side from the North Peach Bottom slate quarries. There are also Chapman slates in the flooring of this building.

Henry & Co.'s quarry, near Slatington, produces material for roofing slate, which is at present transported on wagons 5 miles from the quarry to the railroad station on the Lehigh and Susquehanna railroad opposite Slatington. The largest slab that has been quarried was 10 by 4 feet by 6 inches. The form of natural slabs is irregular. The method of drainage is pumping by water- and steam-power; the hoisting is by steam, and the dressing by hand.

Caskie & Emack's quarry is located  $1\frac{1}{2}$  miles northeast of Slatington. The form of the natural slab is rectangular; the dimensions of the largest slab quarried is 30 by 8 feet by 20 inches thick. The quarry is drained by means of a pump worked by steam-power; the hoisting is done by steam-power, and mantel stuff is worked by circular saws and iron planers run by steam.

James Hess & Co.'s (Slatington) quarry produces material for roofing and other architectural purposes. The dimensions of the largest slab quarried here are 10 by 18 feet by 6 inches, but slabs 18 by 20 feet by 12 inches might be moved. The product is marketed throughout the United States. The hoisting and pumping are done by steam. This firm has a factory for manufacturing school slates, and one for manufacturing mantel stuff, blackboards, and tiling.

The Penryn quarry, at Slatington, operated by W. H. Seibert, produces roofing slate, school slates, and the material for blackboards for public schools; also hearth-stones, mantel stuff, and register-stones. The peculiarity of some of the material of this quarry is that some of the beds are a shade or two darker and softer in texture than others, and are easily distinguished in the quarry. The dark stone or beds, when used for roofing, discolor when exposed, while beds of lighter shade, which are harder, when made into roofing slates hold their color, and are very durable. Frequently hard and soft beds lie side by side in the ledge.

In the quarry of David Williams, at Slatington, the form of the natural slabs is irregular. The transportation from the quarry is by rail, on the Lehigh Valley, the Berks and Lehigh, and the Lehigh and Schuylkill railroads. The power employed in draining, in hoisting, and dressing mantels and blackboards is steam; the drilling and dressing of roofing and school slates are done by hand.

The Columbia Slate Company's quarry is situated half a mile west of Slatington, on a branch of the Lehigh Valley railroad, from whence the slates are shipped to various states and some exported to foreign countries. The hoisting and draining are done by steam, the drilling and dressing by hand.

At the Franklin quarry, half a mile west of Slatington, there are two different varieties of dark blue roofing slate, but no soft beds of school slates. The form of the natural slabs is rhomboidal.

Griesimer & Brothers' quarry produces roofing slate exclusively. The form of the natural slab is rectangular. The dimensions of the largest slab which has been quarried are 16 by 5 feet by 4 inches, but slabs 22 by 15 feet by 6 inches might be moved. The slate is transported on the Lehigh and Schuylkill railroad.

Keever & Lutz's quarry produces roofing slate, which is marketed in Berks and Lehigh counties, being transported by wagon and by railroad. The form of the natural slabs is irregular. Hoisting is done by steam, the drilling and dressing by hand.

Laurel Hill Slate Company's quarry produces slate for roofing purposes. The form of the natural slab is irregular. Hoisting is done by steam, the drilling and dressing by hand.

The Lock Slate Company's quarry produces slate for roofing, school slates, tiles, platforms, and steps. The form of the natural slabs is irregular; slabs 27 by 8 feet by 5 feet thick might be moved. A branch of the Lehigh



Valley railroad is built to the quarry. Draining, hoisting, sawing, and planing are done by steam, the drilling and dressing by hand. The machinery consists chiefly of saw-beds, planes, and patent machines for dressing roofing and school slates.

Joel Neff's quarry, near Slatington, consists of three openings on the same ledge of slate. The material is quarried for roofing, and is marketed chiefly in the United States, though some is exported. The form of the natural slabs is irregular; size of the largest slab quarried, 500 cubic feet, but a slab of 600 cubic feet might be moved. The draining and hoisting are done by steam, the dressing partly by steam, and the drilling by hand.

Krum & Moser's quarry, formerly known as the Blue Mountain quarry, produces roofing slate exclusively, which is marketed in the middle, western, and northwestern states, and is transported by railroad and canal. The form of the natural slabs is rectangular, and the dimensions of the largest slab that has been quarried were 18 by 5 feet by 18 inches. Hoisting and pumping are done by steam, the drilling and dressing by hand.

The Industrial Slate Company's quarry, west of Slatington, is operated for roofing slate exclusively. The form of natural slabs is rectangular, and the dimensions of the largest slab that has been quarried were 15 by 4 feet by 6 inches. The draining and hoisting are done by horse-power, the drilling and dressing by hand.

**PEACH BOTTOM QUARRIES.**—The ledge of slate in which the Peach Bottom quarries are situated furnishes the dark blue, indurated clay-slate almost devoid of calcareous material, as it is of Archæan age, and therefore older than any of the calcareous rocks of Pennsylvania. The following is an analysis of Peach Bottom slates, specimen from J. Humphrey & Co.'s quarry, half a mile east of Delta, York county, from Report C C C, *Second Geological Survey of Pennsylvania*:

	Per cent.
Silicic acid.....	55.880
Titanic acid.....	1.270
Sulphuric acid.....	0.022
Alumina.....	21.849
Ferrous oxide.....	9.034
Manganous oxide.....	0.586
Cobaltous oxide.....	Trace.
Lime.....	0.155
Magnesia.....	1.495
Soda.....	0.460
Potash.....	3.640
Carbon.....	1.974
Water.....	3.385
Iron bisulphide.....	0.051
Total.....	<u>99.800</u>

The percentage of lime in its composition is small compared with that in many other slates, some of which are quite perceptibly calcareous. The nearest belt of calcareous rocks is the magnesian limestone of Lower Silurian age, to the northwestward. Serpentine rock lies on one side of this slate ridge, and asbestos on the other. The ledge at Peach Bottom is several hundred feet in width, varying somewhat in this respect, however, and extending along on the summit of the low ridge which extends in a northeasterly and southwesterly direction. The slate begins in the southwestern part of Lancaster county, Pennsylvania, crossing the Susquehanna river not far from Mason and Dixon's line, passing through the southeastern part of York county, Pennsylvania, and extending into Harford county, Maryland. At the Susquehanna river, on the Lancaster County side, slate was once quarried. The ledge at this point is quite high and steep, but rapidly lowers in passing into York county. The bed of the Columbia and Port Deposit railroad, which passes here, interferes with the disposition of waste.

A few miles farther to the southwest, at Bangor and Delta, and just across the line in Maryland, what is known as the Peach Bottom slate is at present quarried. In quarrying slate for roofing there is always considerable waste on account of material unsuited to the purpose. The quarrymen select locations where there is likely to be the greatest proportion of workable material, of which they judge by the appearance of the slate which extends to the surface. The cleavage planes in most of the quarries are nearly vertical, and are parallel to the stratification; and in some of the quarries there is a set of joints cutting the cleavage planes at angles varying from about 45° to 60°. A noticeable circumstance is that the joints in these quarries are less numerous to the westward. In some of the quarries there is beautiful slate stock which cannot be readily split for roofing slate, but which answers well for other purposes. The following are a few of the buildings in which Peach Bottom slate has been used for roofing: The building of the Bureau of Engraving and Printing at Washington city; the court-house and post-office at Des Moines, Iowa; the Academy of Fine Arts in Philadelphia, and the Westinghouse Air-Brake Company's building, Allegheny, Pennsylvania. This slate ranks high for strength and durability, is not subject to change in color upon exposure, and is tough and fine and smooth in texture. Old buildings in the neighborhood of the quarries have roofs of it which were put on seventy-five years ago, and show no perceptible change in color. It is practically free from sulphur, iron, and lime, the ingredients which when present cause fading and decomposition of roofing slate by exposure. The slates here are manufactured by breaking up the rock first

by blasting, then by different processes into pieces of suitable shape and size for splitting by hand, using for this purpose thin chisels of steel, after which they are dressed or cut into shape and size by a machine. The common sizes are 12, 14, 16, 18, 20, 22, and 24 inches in length, and four or five different breadths to each length are made. The average thickness of slate here is about fifty-five pieces to the foot. The material is sold by the square superficial area of 100 feet, weighing about 625 pounds. Some architects in making out specifications call for thicker slates than those made for the trade. All the sizes made rank the same as to quality and manufacture. Vol. I, *First Geological Survey of Pennsylvania*, gives a short description of the quarries that were operated on the Peach Bottom slate belt about the year 1850; and also some statistics concerning the amount of material quarried and the value. It is stated that the prices of slate for the six years ending in 1853 ranged between \$14 and \$17 per ton—that is to say, from about \$4 to \$6 per square; that slates of the largest size, 24 by 14 inches, were \$69 per thousand; those 16 by 8 inches, \$22 per thousand; and those 12 by 6 inches, \$12 per thousand.

The following description of the slate belt of Peach Bottom, by Professor Henry D. Rogers, is in the *Report of the First Geological Survey of Pennsylvania* for the year 1853:

*Slate belt of Peach Bottom.*—The next subordinate belt which the section crosses is the slate range of Peach Bottom and Slate point. The rock here is a dark blue, indurated clay-slate, much of which has the structure of roofing slate, extensive quarries of which have long been successfully wrought at the Peach Bottom cliffs on the eastern side of the river, and also at numerous points west of the river, in York county, and in Maryland. The workable slate belt here is about half a mile wide. The slaty cleavage and the bedding appear throughout to be nearly coincident in their dip, which at the quarries is nearly perpendicular a little southward. The quality of the Peach Bottom slates is very good, and their exportation is slowly augmenting. The belt runs northeastward through the Slate hill from the river, a distance of about 2 miles, and southwestward through York county from Slate point, a distance of about 6½ miles, to the state line. Slate quarries have been opened northeast of the river, along nearly the whole distance mentioned, but never extensively wrought, and in the same detached manner through York county. At Slate hill on the river the slate is quarried in steps or benches, and not in one general breast, though the material is so uniformly pure as to admit of being nearly all wrought. On the east side of the river there are seven quarries near the shore, and four others of smaller size back on the hills, which are at the present time unwrought. On the York County side there is only one quarry at the river, but in the interior of the county there are seventeen more, embraced between a point 2½ miles back and the end of the range 6 miles from the river. The workable slate appears not to extend in Lancaster county northeast of the limit given, but in the other direction there are indications that it is prolonged beyond the distance of the 6 miles named. One of the quarries on the river, Brown's Lower quarry, yields slates which will bear strong stove heat without cracking, and the workmen use flags of it for frying their meat upon; so uniform is the composition of the material, and so diffused and regular the metamorphism, that the original planes of sedimentation or bedding are too indistinct at these river quarries to be discernible. The cleavage-planes, the only visible ones, dip about 80° south to 30° east, and this condition prevails throughout.

GENERAL CONSIDERATIONS.—In a treatise on slate and slate quarrying by D. O. Davies, F. G. S., London, 1880, he assigns causes for the recent rapid increase in the slate trade in Great Britain. He states that the progress made by this trade during the last quarter of a century in that country has been very marked and rapid; and with the exception of slight checks given to it during the civil war in America, the war between Prussia and Denmark, and that between Germany and France, the progress has been continuous; that during the last ten years the price of slates has increased 30 per cent., and that the present state of the trade may be described as one of such great prosperity as to be limited only by the ability to supply the demand, the demand being far in excess of the supply. This increasing prosperity of the slate trade Mr. Davies ascribes to the rapid extension of railways over the country, which places slates within the reach of numbers of inland towns from which, excepting for special purposes, they were virtually excluded on account of the cost of carriage. The inland town of Shrewsbury was, until the extension of the railway system, a tile-roofed town, while Chester, to which access is had by water, has been for generations a slated town. In Shrewsbury and most of the other inland and formerly tile-roofed towns slates have superseded tiles. The fact that slate is so rapidly and steadily superseding other roofing materials is chiefly due to the increased facility for transportation afforded by the railways, and it is plain that the same causes influence the development of the slate industry in the United States. The railways not only afford ready means of transportation from the slate regions to inland cities which were before entirely excluded from the use of slate, but new business centers spring up along the lines of the railways and thus increase the demand for slates.

There have been within the last ten years some singular conditions in the slate trade both in this country and in Great Britain. The demand increased so rapidly in the British islands during the past ten years that it was far in excess of the supply, while in the United States during that time the trade was in its infancy, increasing rapidly, however; but from 1876 to 1880, owing to business depression chiefly, to an almost entire cessation in building enterprise, and to the custom of using the cheapest materials, the demand was not equal to the production of the slate regions of the country, bringing down the prices of slates so low that they were shipped to Great Britain, even selling at a lower rate than the Welsh slates; and considerable foreign trade sprung up in this way. However, as the prices of American slates in England could not rise any higher than the prices of the Welsh slates in that country without stopping the American trade altogether, exportation was unprofitable to the quarrymen. During 1880 the general resumption of business throughout this country created a sudden demand for American slates at home, the prices ran up to almost double the former rates, and the demand far exceeded the supply.

The Welsh and the American slates are quarried from formations of the same age—that is, strata of Cambrian and Lower Silurian age. The quarries in Buckingham county, Virginia, and in the slate regions of Harford county,

Maryland, York county, Pennsylvania, Piscataquis county, Maine, Rutland county, Vermont, and Washington county, New York, are probably of Cambrian age, while the region of Lehigh and Northampton counties, in Pennsylvania, is of the Hudson River division of the Lower Silurian age.

The Welsh slate regions at Festiniog, Portinadoc, Carnarvon, Penrhyn, and other places are from Harlech, and Llanberris, and Trenbech beds of Cambrian age, and the Upper and Lower Llandeilo and the Wenlock strata of Lower Silurian age. A comparison of chemical analyses of the Welsh and American slates aids to determine their relative values as roofing materials. The fact that Welsh slates are shipped to the United States, and at times figure considerably in the American market, and that American slates are exported to Great Britain and Ireland, makes this question one of importance. The following are some analyses of Welsh slates given by Mr. Davies:

#### ANALYSIS OF ORDINARY WELSH ROOFING SLATE (BLUE).

[Given by Professor Hull. (a)]

	Per cent.
Silica.....	60.50
Alumina.....	19.70
Iron (protoxide).....	7.83
Lime.....	1.12
Magnesia.....	2.20
Potash.....	3.18
Soda.....	2.20
Water.....	3.30
Total.....	100.03

#### ANALYSIS OF DARK BLUE SLATE FROM LLANGYNOG, NORTH WALES.

[By Mr. D. H. Richards, analytical chemist, of Oswestry.]

Analysis of slate dried at 100 C. :

	Per cent.
Loss on ignition.....	3.720
Silica.....	60.150
Protoxide of iron.....	5.837
Sesquioxide of iron.....	1.815
Alumina.....	24.200
Not determined—alkalies, etc.....	4.278
Total.....	100.000

#### ANALYSIS OF THE MATERIAL OF THE GREEN BANDS IN THE BLuish-PURPLE SLATES OF LLANBERRIS.

[Made at the Royal School of Mines for Mr. George Maw, F. G. S., of Brossley.] (b)

	Per cent.
Silica.....	66.45
Titanic acid.....	0.63
Alumina.....	13.38
Protoxide of iron.....	1.71
Peroxide of iron.....	1.41
Protos sesquioxide of manganese.....	0.91
Lime.....	2.86
Magnesia.....	6.28
Potash.....	0.05
Soda.....	0.90
Carbonic acid.....	1.30
Combined water.....	3.90
Hygroscopic water.....	0.13
Total.....	99.91

#### ANALYSIS OF THE PURPLE SLATES OF NANTLLE.

[Given in Kirwan's *Mineralogy*, Vol. I, p. 210.]

	Per cent.
Silica.....	0.48
Argillaceous matter.....	0.26
Magnesia.....	0.08
Lime.....	0.04
Iron.....	0.14
Total.....	100.00

For analysis of Peach Bottom, Pennsylvania, slate, see page 110.

MARYLAND.

[Compiled mainly from notes of Messrs, Huntington, Monroe, and Singleton.]

About one-half the area of the state of Maryland is made up of rocks of the Cretaceous and the Tertiary ages, which in this state furnish no stones of importance for purposes of construction. A line drawn from near Elkton, in the northeast corner of the state, southwesterly through Baltimore to Washington, following nearly the course first of the Philadelphia, Wilmington, and Baltimore railroad and then of the Baltimore and Ohio railroad, would approximately separate the Cretaceous and the Tertiary areas from the Archæan, adjoining them on the northwest. Passing westward from the line described, about the same order of succession of strata as that in Pennsylvania occurs; as follows: The Archæan rocks, furnishing granites, gneisses, serpentines, and slate; next the narrow belt of the Triassic rocks, from which are obtained the Seneca red sandstone and the Potomac breccia marble; the Lower Silurian strata, in which are found the great Magnesian limestone and marbles; the Upper Silurian, Devonian, and in the mountain region near Cumberland, in the northwest corner of the state, the Carboniferous, none of which have as yet furnished much stone for building purposes. A thorough geological survey of this state has never been made.

CRYSTALLINE SILICEOUS ROCKS.

At Port Deposit, Cecil county, near the mouth of the Susquehanna river, a gray biotite gneiss is extensively quarried, and is used chiefly for heavy masonry, such as bridge construction, docks, harbor improvements, and general purposes of construction. It has been much used by the United States government in public works. Among the structures in which this stone has been used are the Susquehanna bridge at Havre de Grace; the Girard Avenue, Fairmount, South Street, and other bridges in Philadelphia, and the principal bridges in Baltimore; Haverford college, Maryland, Taylor college, Bryn Mawr, the depot building of the Philadelphia, Wilmington, and Baltimore railroad, and Saint Dominick's church, in Washington city. There are several churches in Port Deposit built of stone from these quarries, which show that buildings constructed entirely of this material make a very pleasing appearance. The material is of a dark gray color, rather coarse in texture, and very distinctly laminated. The principal set of joints in these quarries has an inclination of about 60°; but a short distance farther up the Susquehanna river these joints become vertical, or nearly so. A notable circumstance connected with the quarries here is that the planes in which the mica is arranged are vertical.

The gneiss which is exposed in the vicinity of Baltimore is the principal resource of that city for ordinary foundations and the rougher sort of stone-work; it is chiefly of gray color, occasionally greenish-gray. The strata are tilted at various angles and the jointing is irregular. Blocks of any size desired may be obtained. Among the buildings in the construction of which this material was used are the United States court-house and the jail in Baltimore; but that used in the United States court-house may perhaps properly be called a granite, as it is very indistinctly laminated. The quarry from which it was taken is at Granite post-office, in Baltimore county, and the material from the same quarry has been shipped to Cincinnati and to Chicago. It is here gray in color, with a slight pinkish tint.

At a quarry of the same material half a mile from this point the whole mass has weathered, leaving immense boulders, but in the immediate vicinity the general decay is less than is usual in this section; however, there is a noticeable decay along the natural joints, and in this respect it resembles more the gneisses which are quarried farther to the northward on this formation. On one side of the quarry at Granite post-office there is a large mass of mica schist, which differs considerably from the prevailing stone in the quarry. The material nearer to Baltimore is more decidedly gneissoid, and is used more largely in that city for the purposes before mentioned. This stone is what is usually known as the blue gneiss or mica schist of the Atlantic coast, and there are exposures of it at nearly every point along the line approximately parallel to the coast-line and at the junction of the Tertiary and the Archæan rocks. It is the same that is used in Philadelphia, Baltimore, and Washington for the ruder purposes of construction, and varies in character from the different kinds of gneiss to a mica schist. The most noted granite quarries in Maryland are located near Woodstock, Howard county; the quarries, however, being in Baltimore county. A gray biotite granite, sometimes having a pinkish tint, is here extensively quarried for general building purposes and for monumental work, and is shipped chiefly to Baltimore, Washington, and the west. Among the buildings in the construction of which it has been used are those of the Bureau of Engraving and Printing and the National Museum, Washington, District of Columbia; the soldiers' monument, Winchester, Virginia, and the safe-deposit building in the office of the Baltimore and Ohio Railroad Company, Baltimore. This stone varies from an indistinctly-laminated to a massive rock, is a good, safe stone to work, and takes a good polish. The strata are tilted at various angles and the jointing is irregular. Blocks of any desired size may be obtained. In one of the quarries the material lies in the shape of boulders—a condition which has been brought about by the weathering of the rock. As no glacial action has ever been brought to bear on the strata in this section of the country to remove the weathered portions, the rock is often found covered with a considerable depth of decomposed material.

Near Ellicott City, on the east side of the Patapsco, a biotite gneiss is quarried for curbstones, steps, and for general building purposes, and is shipped to Baltimore and Washington. It was used to some extent in the cathedral in Baltimore. The quarries are in Baltimore county, but Ellicott City, the post-office of this region, is in Howard county. Some of the rock in this vicinity is porphyritic and contains crystals of feldspar an inch and a half or more in length, but they are irregularly distributed through the mass; yet there are places where blocks of some

size can be obtained in which the feldspar crystals are quite regular, in which cases the stone is of uniform and handsome appearance. Much of the rock from these quarries has been used in Baltimore and along the Baltimore and Ohio railroad. For 15 miles west of Relay station, on this road, many of the houses are built of this stone; in all, there are about 100 buildings constructed of it, and Professor Huntington reports that he knows of no other place in the country where there are so many stone buildings in an area of the same size. Among the other places from which specimens of gneiss and granite have been obtained are the Relay House, the Winans estate at the mouth of Gwynn's falls, Orange Grove station, and Ilchester, on the Baltimore and Ohio railroad.

With regard to texture the material here varies very much, some of it being quite fine and some coarse. The general dip of the rock is north-northeast.

At the mouth of Gwynn's falls some of the rock is properly a granite, but passes into a gneiss on one hand and a binary micaceous granite on the other, presenting a width of 30 feet on the front. The general dip is about 45° north-northwest. Professor P. H. Uhler regards all the granites of this region as inclosures—that is, entirely surrounded by rocks of a different character—and cites numerous examples to sustain his views; he does not find any intrusive rocks. The strike is north-northeast.

A specimen of granite was forwarded from Montrose post-office, 3 miles east of Rockville, Montgomery county, by Professor Munroe, who reports that the mass of granite here has simply been exposed. It is comparatively easy of access, the location of the exposure being on the hillside, but there is considerable depth of stripping.

Soap-stone exists here also, and was formerly quarried. It comes in direct contact with the granite.

In the Archæan rocks of Maryland is a variety of serpentines, some specimens of which in the census collection in the National Museum have been polished, and present the most brilliant green appearance.

Near Dublin, Harford county, 32 miles northeast of Baltimore and 62 miles southwest of Philadelphia, a compact and massive green serpentine (sometimes called "precious serpentine") is obtained. This material is fine in texture, of great hardness and tenacity, of a beautiful green color, and is susceptible of a fine and brilliant polish. It is a late discovery, and the quarries are not yet fully developed, but blocks that will dress to the size of 5 by 4 by 2 or 3 feet may now be obtained. The Green Serpentine Marble Company, of Harford county, Maryland, is making extensive preparations for quarrying this material, and Professor F. A. Genth, of the university of Pennsylvania, has published a report on the material. He reports that the supply of serpentine is practically inexhaustible, that it is situated in a most favorable position for quarrying on a large scale, and with an abundant supply of water-power to manufacture it into marketable forms. Professor Genth's description of the mineralogical character of this stone is as follows:

It is a variety of massive serpentine, somewhat resembling williamsite, and shows sometimes a slightly slaty structure. It occurs in various shades of green, from a pale leek-green to a deep blackish green, and, from a small admixture of magnetic iron, more or less clouded; rarely with thin veins of dolomite passing through the mass. It is translucent to semi-transparent; it is exceedingly tough, and its hardness is considerably greater than that of marble, scratching the latter with great facility. The analysis of a deep green translucent variety gave the following results:

	Per cent.
Silicic acid.....	40.06
Alumina.....	1.37
Chromic oxide.....	0.20
Niccolous oxide.....	0.71
Ferrous oxide.....	3.43
Manganous oxide.....	0.09
Magnesia.....	39.02
Water.....	12.10
Magnetic iron.....	3.02
Total.....	<u>100.00</u>

Hardness (or that of fluor-spar), 4.00; specific gravity, 2.668.

Its green color is due to the oxides of chromium, nickel, and iron present.

In a polished condition it appears to me to be practically almost unalterable, as the polished surfaces do not admit of the absorption of atmospheric agencies which cause the decomposition.

I have above stated that a black, mottled serpentine underlies the green, forming a bed of about 800 feet in thickness. It is not sufficiently developed, but is very conspicuous alongside of Broad creek. It weathers more readily than the green, changing into a white rock spotted with black. The fresh rock, in thin plates, is of a very pale greenish-white color clouded with black. It is softer and less tenacious than the green.

The analysis shows it to be a variety of serpentine, like the green, with an admixture of a larger percentage of magnetic iron. It contains:

Silicic acid.....	40.39
Alumina.....	1.01
Chromic oxide.....	Trace
Niccolous oxide.....	0.23
Ferrous oxide.....	0.97
Manganous oxide.....	Trace
Magnesia.....	38.32
Water.....	12.86
Magnetic iron.....	6.22
Total.....	<u>100.00</u>

Hardness, 4; specific gravity, 2.669.

It is also susceptible of a good polish, and for some purposes may become a valuable ornamental stone.



About 6 miles north from Baltimore, and near the line of the Northern Central railway, is found a serpentine varying from a light to a dark green in color, but it has been but little quarried as yet.

This rock is very well adapted to be used as ashlar in the walls of churches and other buildings. In a church in Baltimore a small portion of this stone has been used with the serpentine from Brinton's quarry, Chester county, Pennsylvania, similar in appearance in every respect. The area of this rock exposed at this point is about 100 acres. Experience with this material goes to prove that it is durable and stands exposure well, but the surface rock shows considerable disintegration; this, however, is not an argument against the durability of the stone in this region, where, as before stated, no glacial or other denuding influences have removed the product of decomposition. An area of serpentine near Deer Creek, Harford county, is represented by a specimen in the collection.

Fifteen miles northwest of Baltimore, on the Liberty road, a steatite or soap-stone is quarried. It is used in lining furnaces and stoves, for registers, and the manufacture of sinks, ice-trays, etc. The color is a greenish-gray. It has defects, which are due to honey-combing occasioned by pyrite cavities.

In the vicinity of Cockeysville and Texas, 16 miles north of Baltimore, on the Northern Central railroad, is a small isolated area of Lower Silurian limestone bounded by rocks of Archæan age, and on this area are located well-known marble quarries. This stone was employed in the construction of Christ church and in the columns and platforms of the city hall, Baltimore, Maryland; the Father Matthew centennial fountain, Fairmount park, Philadelphia; exterior walls of the Washington monument, and the columns and heavy platforms of the Capitol extension at Washington. Blocks 28 by 10 by 3 feet have been quarried, and blocks as large as can be transported by the usual means might be obtained. The stone lies chiefly in large rectangular and nearly horizontal masses. It is usually of a coarsely crystalline texture and of a white or light color. The drilling and sawing are done by steam-power. It is worthy of note that almost all of the marbles of commerce so extensively quarried east of the Alleghanies are from strata of Lower Silurian age, the principal exception being the Snow Flake marble quarried in Archæan strata at Tuckahoe, Westchester county, New York.

At Hagerstown, Washington county, in the great Lower Silurian limestone valley, lying to the west of the South mountain, the limestone is quarried for local use. It is here a magnesian limestone, and specimens analyzed by Mr. Dewey at the National Museum contained alumina and graphite. It was employed in the construction of the Protestant Episcopal and Methodist Episcopal churches in Hagerstown. Professor Charles E. Munroe reports these quarries on a belt locally called Cedar stone, a few hundred feet in width, extending for a distance of several miles, and believed to be peculiar in the fact that the upper layers furnish the most durable stone. There are a number of other localities in the region surrounding Hagerstown and in the same geological horizon as are the Hagerstown quarries. Worthy of mention in this connection is a black limestone found in the Chesapeake and Ohio canal from 4 to 6 miles below Williamsport.

Fogel's quarry, at Four Locks post-office, on the same canal, was worked extensively for stone to be used in the construction of the locks. A variety of light-colored limestone, locally called "Knuckle stone", is found near Benevola post-office; and at the same place there is a quarry of white and variegated marble which was worked for 40 years; it closed in 1868, owing to lack of good facilities for transporting the stone, the quarry being 15 miles from the nearest railroad.

At Keedysville, on the Washington County railroad, a gray magnesian limestone containing black lines is quarried, and is used largely in Hagerstown for steps, underpinnings, and curbs; it resembles the white limestone of Carroll county in the fact that it works easily only in the plane of stratification. It contains a little iron and a silicate.

There are many localities in Maryland where ledges of building stones are but little developed, and from which specimens were collected for the Tenth Census. Among these may be mentioned a siliceous limestone, containing protoxide of iron and a little magnesia, from Liberty pike, Mount Pleasant district, in Frederick county.

Getzendaner's quarry, on the Hagerstown pike, near Frederick, furnishes the "Potomac" or "calico" marble, a calcareous breccia of Triassic age which was quarried at Point of Rocks to obtain the material of which the columns in the old hall of Representatives at the Capitol building, Washington, were constructed. Representative specimens furnished from the Getzendaner quarry show the stone to be here, as in the other points in Maryland and Pennsylvania where it is exposed, a breccia made up of fragments chiefly from the great magnesian limestone to the northwest; its chemical composition being almost the same as the latter.

In a report of the geological survey of Maryland, made in 1833, by Ducatel and Alexander, it is stated that the Potomac breccia marble occurs along the Potomac river, commencing a short distance above the mouth of the Monocacy, reaching nearly to the Point of Rocks, and extending along the valley on the eastern side of the Catoctin mountain to within 2 miles (west) of Fredericktown, at which point it is contiguous to the red sandstone and the blue limestone; and that the formation reappears near Mechanicstown.

Near New Windsor and Union Bridge, in Carroll county, and in the neighboring portions of Frederick county, is found a magnesian limestone which has apparently been subjected to considerable metamorphic action. The signs of stratification are often destroyed, and the color varies from a white with pinkish patches or bands to a pink. A chemical analysis discovers but little variation in the chemical composition of different specimens of this stone; they usually contain much lime, sufficient magnesian carbonate to entitle them to the name "magnesian limestone", a little iron, sometimes in the form of a protoxide, and occasionally a silicate.

## SANDSTONE.

There are no large or important sandstone quarries at present operated in Maryland, though, at several localities in the state, sandstone of superior quality for purposes of construction exists in inexhaustible quantities. The most noted quarry of this material is the celebrated Seneca sandstone quarry on the Potomac at the mouth of Seneca creek, 20 miles above Washington city. This material belongs to the Triassic formation described in other portions of this report. The stone was extensively used in the construction of many large public buildings in Washington, including the Smithsonian Institution; the Freedman's Bank building, now the Department of Justice; the Fourteenth Street Lutheran Memorial church; the District jail; and a reference to the remarks on stone construction in the city of Washington will show the other purposes for which it has been used there. There are good facilities for transportation from this quarry to Washington and to all other points along the Chesapeake and Ohio canal.

Specimens of quartzite of Archæan age were collected at Dickerson post-office, Montgomery county, on the Metropolitan branch of the Baltimore and Ohio railroad and the Chesapeake and Ohio canal. It has been used to some extent in the construction of aqueducts, bridges, and furnaces. The aqueduct of the Chesapeake and Ohio canal over the Monocacy river was built of this stone. It is of rather coarse and uniform texture; and its use in the aqueduct shows that it is proof against the action of dampness and freezing, as that structure was built nearly fifty years ago, and there are yet no visible signs of decay of the material. This stone would be suitable for curbs and paving blocks.

At Cumberland, Alleghany county, white sandstone of Medina age is quarried for curbs, steps, and trimmings. It has been used also for bases and cemetery work, and was used in the trimmings of the Protestant Episcopal church and in the construction of the Methodist Episcopal church and the market-house in Cumberland. The material thus far obtained has been very large detached bowlders, found about 7 miles north of Cumberland. The ledge exposed in Wills mountain is about 500 feet in thickness, but this has not yet been quarried, as the material is more readily obtained from the detached rocks before mentioned. Through the narrow valley, about 300 yards wide at the base of this mountain, two railroads run. The stone varies considerably as to its firmness, depending upon the depth in the bed; the upper part is so soft as sometimes to yield to the hand, but the lower part is quite strong and compact.

Professor C. F. Chandler, in a report on the mineral resources of Cumberland, gives the following analysis:

	Per cent.
Silica.....	98.35
Sesquioxide of iron.....	0.42
Total.....	98.77

Another exposure of the same stone is found east of Cumberland, on the Chesapeake and Ohio canal; and there is also a yellow sandstone of Oriskany age, which has been used to a limited extent for building purposes in Cumberland, especially in the construction of the Methodist Episcopal church. It is not quarried at present. The stone varies very much as to firmness; the stratum which is sufficiently firm for building purposes lies at a depth of about 30 feet and is about 18 inches in thickness. When apertures in which water can collect exist in this stone the frost soon disintegrates it, but if the surface is dressed it is quite durable, and buildings in Cumberland in which it has been used, some of them built 15 or 20 years ago, are now in a perfect state of preservation. The stone in this quarry has a dark yellow color. The strike of the strata in this vicinity is a little east of north, following about the course of the mountains. There is but little dip in the strata of either the Medina or the Oriskany sandstones so far as can be seen from the exposure. A dark red sandstone crops out at Frankville and continues to Oakland, in Garrett county. It has been quarried at intervals by the railroad company, for use chiefly in protecting-walls for embankments, and in these structures it seems firm and durable. Tyson gives this material as Potsdam sandstone.

Professor Munroe reports that a white sandstone of excellent quality is quarried to a limited extent at Knowlesburg, and he traced it to the westward from this point as far as Newburg, in West Virginia. He also states that east of Tunnellton it begins to appear above the bituminous coal, which fact proves it to be of Carboniferous age.

## SLATE.

The principal slate quarries in Maryland are in the Peach Bottom district, in Harford county, near the state line. The ridge upon which these quarries are situated extends into York county, Pennsylvania, and a number of the quarries are on the Pennsylvania side. The whole is described in the treatise on the building stones of Pennsylvania. The principal quarries both in Maryland and in Pennsylvania are all within a radius of a mile, and produce exactly similar material. For roofing purposes this slate is of a highly superior quality.

On the Baltimore and Ohio railroad, at the village of Ijamsville, Frederick county, there is an exposure of roofing slate which was formerly quarried for this purpose, and several roofs in the vicinity were made during the eighteenth century, and are now in good condition, which speaks well for the quality of the material. These slates are of a beautiful sky-blue color, and are reported not to fade. No roofing slate has been made here since 1873.

## VIRGINIA.

[Compiled mainly from notes of Messrs. Huntington and Munroe.]

In Virginia, as in Maryland, the surface rocks of quite a large area of that part of the state lying next the Chesapeake bay and the Atlantic ocean are of Tertiary age and furnish no good building stones. The coarse and durable gray sandstones formerly quarried by the United States government at Aquia creek for the construction of the White House, the old portion of the Capitol, and other public buildings in Washington that were built in the early part of the century, are probably of this age; though, as no complete geological survey of the state has ever been made, the stratigraphical relations of many of its rocks cannot be pronounced upon with certainty. The preliminary reports by Professor W. B. Rogers previous to 1838, and the work done in neighboring states where the conditions of the strata are to some extent analogous, have developed the same general facts concerning the geology of the state. The band of Archæan rocks setting in to the westward of the Tertiary and running approximately parallel with the Appalachian mountains, furnishes granites, gneisses, and slates. The narrow Triassic belt resting upon the Archæan rocks in places supplies the red or brown sandstone which is quarried extensively at Manassas, and the diabase or trap quarried near Catlett station, Fauquier county, and near Leesburg, Loudoun county.

The Triassic sandstone extensively quarried for building purposes at Manassas bears a strong resemblance to the Seneca sandstone at the mouth of Seneca creek in Maryland, it being of the same horizon. The location of the Manassas quarry is near the top of a slight eminence. The strata here are nearly horizontal; there is, however, a slight dip to the south. Only the upper portion of the ledge to the depth of about 20 feet has as yet been quarried. The courses are of various thicknesses up to 6 feet, but the usual thickness is from 5 to 6 feet. Blocks 40 by 20 by 4 feet in thickness have been loosened in the quarry, and a block containing 88 cubic feet was shipped. Between the courses a greenish shale occurs which has a smooth, soapy feel, and when exposed to the atmosphere turns red. The principal markets for this material thus far are Washington, Baltimore, Danville, Virginia, and Charleston, West Virginia. Among the buildings in the construction of which the stone has been used are the District jail, Washington, and the government buildings at Danville, Virginia, and at Charleston, West Virginia. In these structures it was used for trimmings.

The quarries of diabase or trap before mentioned are located on dikes which cut the Triassic formation. That on which the Catlett Station quarry is located is apparently nearly parallel to Cedar Run creek; so far it has been quarried only for paving blocks and for sewer construction in Washington.

The quarry near Leesburg, Loudoun county, is scarcely developed. A fine dwelling was built of this material by C. R. Paxton, near Leesburg. As is usual with diabases, these stones are hard and difficult to work, but work safely and take a good polish.

To the westward of the strata already described the surface rocks are chiefly Silurian, Devonian, and Carboniferous; none of them have as yet furnished much material for building purposes, although a proper exploration would doubtless discover important resources in them. On the Valley railroad, 2 miles northeast of Staunton, Augusta county, there is an argillaceous limestone of Lower Silurian age, locally called slate, which is quarried for slate stock by the Red Bud Slate Company.

A limestone slightly magnesian in character and of Upper Silurian age is quarried chiefly for interior work, furniture, and other ornamental purposes, at Craigsville, Augusta county.

Returning to the Archæan rocks, it may be said that they have thus far been the most important resource for building stone in Virginia. The principal quarries thus far developed are located in Chesterfield and Henrico counties, in the immediate vicinity of Richmond. These quarries have all the advantages of good water transportation, as they are located on the James river, and the material may be shipped by schooner to all points on the Atlantic coast. The stone is a gray biotite granite having the same general characteristics as the gray granite so extensively quarried in the other Atlantic states farther north. The following are notes concerning some of the most important individual quarries of this region:

The quarry of the Richmond Granite Company, on the Richmond and Alleghany railroad, near Richmond, Virginia, produces a massive gray granite used for general building purposes, paving stone, and monumental work, and is shipped more or less to all the states and cities south of New England and as far west as Nebraska. Much of the material is dressed at the quarry, polishing-works being located on the grounds; and at present there is more activity here than at any other quarry in Virginia. A very large quantity of stone has been taken from this quarry, which has been accessible for many years by canal. This, however, has been discontinued, and a railroad now runs to the quarry. Comparing this rock with that of other quarries in the vicinity of Richmond, it appears that the feldspar crystals are larger than those generally seen elsewhere, but they are often irregular in shape and have a brownish color, which shows very distinctly on the polished surfaces. Blocks of any size desired may be obtained.

The Old Dominion granite quarry has furnished material for many important public buildings throughout the country, with principal markets in Richmond, Washington, Norfolk, Lynchburg, and Philadelphia. Among

the prominent structures in which this material has been used are the post-office buildings at Richmond, Philadelphia, and Harrisburg. This quarry is well located for working, as it lies along the Richmond and Danville railroad, and the stone is lifted from the quarry upon the cars ready for shipment. There are as to color two varieties of stone in this quarry; one, a light gray, penetrates the darker after the manner of veins, but there is scarcely any perceptible difference as to texture. There are some peculiarities in regard to the joints in this quarry, and along each joint below the general surface decay is a thin layer of calcite, the lime of which was probably derived from the plagioclase feldspar so abundant in this granite. The waste from the quarrying and cutting of this stone is disposed of by being crushed by a rock-breaker, which is elevated so that the crushed material falls into a car and is transported to various points along the road and used for ballast. Professor J. H. Huntington, who collected the data from this region, expresses a doubt as to whether this granite is of Archæan age, and states that there is evidence that it is much younger than has been generally supposed, and that a study of the granite south of the Old Dominion quarry, along the border of the coal-fields, and at Fredericksburg, would probably furnish facts not heretofore known, and might determine the age of these rocks.

At Manchester, in Chesterfield county, is located one of the oldest as well as one of the most important quarries in this section. The surface rock is decayed to a considerable depth, and in some instances boulders are left in the general decay; but below the point where the general decay ceases the natural joints seem free from discoloration or change, and are nearly horizontal.

In the Tuckahoe district, Henrico county, is a granite quarry recently opened, though in the same locality is situated one of the oldest quarries of this section, and from it the stone for the Washington monument at Richmond was obtained. The quarry, however, is not now operated. The resistance to decay in this rock is very notable, as there are some outcrops that are quite sound on the surface; the jointing is also peculiar, the principal joints conforming to the general slope of the hill on which the quarry is situated. Next to the river the rock is fine grained, but northwest of a quite well-defined line it becomes coarser.

In Amherst and Campbell counties, near Lynchburg, a bluish-gray biotite gneiss is quarried for general building purposes, and is used in Lynchburg, Danville, Richmond, Alleghany, and other cities of this region. It was used in the construction of the Female Orphan Asylum building at Lynchburg. This rock is quite similar to that found in many places along the Atlantic coast, and resembles very much the Potomac gneiss or mica schist in the vicinity of Washington. The quarries in Amherst county are on the left bank of the James river, opposite the city of Lynchburg. The strata are more or less bent and distorted, but in many places they are quite regular, and readily split into layers of from 3 to 6 inches in thickness.

The Fishing Creek quarry is about a mile and a quarter from the station of the Norfolk and Western railroad in Lynchburg. The strata are regular and dip 42° southeast. The material is remarkable in being quite free from iron, and in this respect differs from this stone elsewhere on the Atlantic coast.

A gray, sometimes greenish-gray, biotite granite is quarried in the Namozine district, Dinwiddie county, for general building purposes, and is used chiefly in Petersburg and Norfolk. It was used in the construction of the post-office and custom-house at Petersburg. A notable feature of the granite in the vicinity of Petersburg is that in many places it stands in bold ledges that have for ages defied the disintegrating agencies which have acted with such effect on nearly all the rocks in this latitude. Nowhere else south of the southern limit of the glacial action by which the decayed portions of surface rocks have been removed can granite be seen in such sharp, well-defined ledges as in the vicinity of Petersburg, and there are very few places in regions where the decayed rock has been removed by glacial action that ledges can be found which show on the surface so little sign of decay. The stone from this locality was used at fortress Monroe for the beds for gun carriages, and it is said that where concussion would fracture other stones, this remains intact. It was also used at the Ripraps, at the outlet of Chesapeake bay. The material is for the most part a solid mass, free from joints.

Specimens of granite representing ledges but little or not at all quarried were collected from Verdon depot, Hanover county; and of mica-schist, considerably quarried for foundations and the ruder purposes, generally, in Washington, from near the Chain bridge in Fauquier county, a few miles above Georgetown, on the Potomac river.

#### SLATE.

In Buckingham, near New Canton and Ore Banks, Buckingham county, a very superior quality of roofing slate is extensively quarried and shipped to the principal cities of Virginia and to Washington, and is quite extensively used as a roofing material in the latter place. It is of a bluish-black color, and has the pearly luster peculiar to the best slates. The following description is by Professor J. L. Campbell:

The fine roofing slates of Buckingham are worthy of special consideration, as well on account of the quality as for the quantity of the material there found. The bolt of slate is on Hunt's creek, a branch of Slate river. The quarries extend up this creek for several miles, with a trend practically parallel with Slate river, and at a distance of from 1 mile to 2 miles east of it. The slates are intersected by numerous veins of igneous quartz, not unlike, in general appearance, the gold-bearing veins; and also by occasional trap dikes, one of which crosses an old opening in the Nicholas quarry. The heat from these igneous rocks has doubtless been a very potent agency in giving the slates that highly indurated, metamorphic condition that renders them so durable, while a uniform lateral pressure acting at right angles to their planes of stratification has given that peculiar structure which results in an easy and regular cleavage when fully quarried.

Some of these quarries have been worked for more than half a century. The principal ones are all that need be named. What is known locally as "Perrow's big quarry", owned by Mr. J. M. Norvell and other persons at Brems, is on Hunt's creek, 1 mile east of Slate

river and 2 miles from the James. A vast quantity of slate has been taken from this quarry, but when we visited the place it was suspended on account of some conflict of claims. The Nicholas quarry, a little farther up the creek, is worked on a large scale, and stones shipped from Bremo by the Richmond and Alleghany railroad. Messrs. Edwards and Robertson's quarry, in the same vicinity, is largely opened, very successfully operated, and its products shipped by the same route. The strata, or rather laminae, of slate in all these quarries are nearly vertical and have a very uniform strike north 25° east, which is about the average bearing of all the strata between Slate and Willis rivers.

At present nearly all the slate from these quarries is split and shaped for roofing purposes, except where special orders are to be filled. Its strength, durability, and uniformity of texture have given it a national reputation. \* \* \*

The same belt of slate appears on the north side of the James, on the Cocke estate, a short distance above Bremo station, but has not been opened to a sufficient depth to test its quality at that point.

Another belt of slate, apparently of the same geological associations and age as the one just described, lies near the southeast base of the Blue ridge, in both Amherst and Bedford counties, cut through by the James river 4 miles below Balcony falls. It is extensively exposed about 2 miles northeast of the river, where a Lynchburg company has opened a quarry that yields a slate of fine appearance and of finer grain than that of the Buckingham quarries. A small opening has also been made on the southwest side of the river, by the Alleghany Coal and Iron Company, sufficient to prove the existence of slate of good quality, and to indicate the presence also of a large quantity. I have subjected samples from this belt to crucial tests, which they bore remarkably well.

There is a number of other points within reach of the railroad at which slate of promising appearance crops out on the surface, but the true character of the material can be determined only by actual openings to such depth as will reach beyond the limits of long-continued weathering.

#### MARBLE AND LIMESTONE.

Marble and limestone quarries have not thus far been much developed in Virginia, though there are several points where these materials have been quarried to a limited extent for local use. The most extensive and best known quarry of this class of rock in Virginia is at Craigsville, Augusta county, where what is known as "coral marble" is quarried, chiefly for interior work in buildings, and for furniture and ornamental purposes generally. It is shipped to New York, Baltimore, Boston, Cleveland, Chicago, Milwaukee, Cincinnati, Saint Louis, and other cities of the country. In texture it is fine, semi-crystalline, fossiliferous, and of a pinkish-gray color. There is quite an extensive area here of this material of uniform character. Specimens dressed at the National Museum show that it takes a good polish. Specimens of limestone, representing ledges which have thus far been but little quarried, were received from the following places in Virginia:

A magnesian limestone from near the Natural bridge, Rockbridge county, locally called marble, but properly a magnesian limestone, sometimes containing a silicate; a magnesian limestone, locally called marble, from Timberville, Rockingham county, and a dolomite from the same locality; a dolomite, locally called marble, from Madison Run station, Orange county; a stalactite from Luray cave, Page county; and a marble from Greenwich, Rockbridge county.

#### SOAP-STONE.

Specimens of steatite or soap-stone were received from various points in the state, but this material has not thus far been used for purposes of construction.

#### NORTH CAROLINA.

The following statements and descriptions are made up from the schedule reports furnished by Professor W. C. Kerr and W. H. Kerr:

The same order of strata occurs in North Carolina, generally speaking, as in Virginia and the South Atlantic states. The Tertiary, Eocene, and other later formations occupy a belt next the sea-coast, and are not important sources of building material. A shell-limestone of Eocene age, used for underpinnings, fences, mill-rocks, and lime, is quarried near New Bern. It seems to be made up entirely of marine shells. This stone can be hewn into shape by axes, but does not stand exposure well.

Material of the same nature is quarried at Rocky Point, Pender county, and has been used to some extent in the breakwater and other harbor improvements at Wilmington. It is transported by flatboats on the Northeast river, and to some extent by rail on the Northwestern railroad. This material is more compact than the New Bern shell-limestone; the rock lies beneath the surface at a depth varying from 1 foot to 6 feet, has a thickness varying from 1 foot to 5 feet, and underlies an area of about 4 square miles. An area of about 100,000 square yards has been quarried over. The rock sometimes overlies a loose, partially-decomposed lime-rock of a foot or two in thickness, and sometimes a bed of marl 2 or 3 feet thick is superimposed. This marl carries from 85 to 90 per cent. of carbonate of lime, and is used as a fertilizer after passing through a pulverizer. Professor W. C. Kerr, state geologist, states that the material withstands considerable crushing weight, and is very serviceable in rough work.

#### TRIASSIC ROCKS.

A narrow belt of Triassic age extends through the center of the state, and furnishes fine, compact red sandstone of superior quality for building purposes. Professor Kerr, who has collected for the National Museum a representative set of building stones from this state, sent specimens from rocks of this age from the following places: Wadesboro', Anson county; Sanford, Moore county; 3½ miles east of Egypt, Chatham county; near Durham, Durham county.



That quarried near Wadesboro' is used for ordinary building purposes, sills, steps, grindstones, and whetstones. It is of fine, compact, uniform texture. The principal markets are Charlotte, Wilmington, and neighboring places. The color of this stone varies from a dark brown to a brick-red, and occasionally a buff. The Triassic sandstone quarried at Sanford is used chiefly in Raleigh, and may be seen in the Raleigh court-house. This stone lies in nearly horizontal strata, which are from 1 or 2 to 4 or 5 feet in thickness, with a depth beneath the surface varying from 1 foot to many feet. It is worked and can be quarried at small cost, stands exposure well, and is being quite extensively introduced as a building and trimming stone. It is soft when first quarried, but in a week or two becomes quite hard and takes a fine dressing.

The sandstone quarried near Egypt is used for building purposes, and is marketed chiefly in Raleigh. It is a durable, fine, brown sandstone, used to some extent for grindstones during the war, and is locally used as a general building material and in the construction of iron furnaces. The strata have a dip to the south of  $12^{\circ}$ , and strike east and west. The stone outcrops in the side of a considerable hill, and is worked with little difficulty.

The Triassic sandstone quarried near Durham is chiefly of a pale gray color, though some of it is brown, and of fine to medium texture, occasionally coarse. Among the buildings in the construction of which it was used are the Raleigh Bank building and the dwelling of Mr. Speight. It has been used for 30 years or more in Raleigh and vicinity. It is comparatively easy to work, and is durable.

#### ARCHÆAN ROCKS.

The Archæan rocks, setting into the westward of this Triassic belt and occupying the whole of the middle and western parts of the state, form one of the most important sources of building stone in North Carolina. They furnish fine gray granite of superior quality at many points. These granites in many cases differ but little from those quarried in the New England states, but have not the advantage of being so near the sea-board as to be accessible by water transportation; they are usually massive, showing scarcely any signs of stratification, but gneiss of good quality for building purposes is abundant. Specimens of granite were forwarded by Professor Kerr from Charlotte and from Davidson College, Mecklenburg county; Lexington, Davidson county; from various points in Alamance county; Louisburg and Cedar Rock, Franklin county; Salisbury, Rowan county; Asheville, Buncombe county; Rockingham, Richmond county; Danbury, Stokes county; Mount Airy, Surry county; Winston, Forsyth county; Concord, Cabarrus county; Garibaldi and Gastonia, Gaston county; Tosneot, Edgecombe county; Greensboro', Guilford county; Mount Mourne and Mooresville, Iredell county; Oxford, Granville county; Warrenton, Warren county; Buckhorn Falls, Harnett county; Shelby, Cleaveland county; red granite from Cotentney creek, near the Weldon railroad, Wilson county; gneiss from near Greensboro' and Jamestown, Guilford county; Henderson, Vance county; Shelby, Cleaveland county; near Louisburg, Franklin county; Henry's station, McDowell county; Morganton, Burke county; Hickory, Caldwell county; Statesville and Mooresville, Iredell county; Northington's ferry, Harnett county; and Raleigh, Wake county.

The granites and gneisses at most of these localities have, so far, only been slightly used for local purposes. The following notes afford some information respecting their nature and availability for building purposes at some of the different localities:

Ten miles northeast of Greensboro', Guilford county, the gneiss shows no observable traces of iron or other material to produce disintegration, and the exposed surface is sound and durable. The blocks lying at the quarry seem nearly as fresh as when first quarried. This quarry was first opened some years before the late war, furnishing good rock for mill-dams in the neighborhood. Subsequently some stone was quarried for other purposes during the war and near its close, but no regular quarrying has been done there since. The material varies from medium fine to rather coarse in texture; it is gray, fairly uniform, works with comparative ease, and splits readily in rectangular blocks and in any desirable thickness. The surface exposure at the opening indicates the presence of an extensive supply of the material. The stratum in which this quarry occurs, or the line of its outcrop, was traced for some distance in a general northeast direction, and in it two or three thin exposures were found, indicating the probable presence of good material in considerable quantity.

Ten miles west of Greensboro' is found a gray, medium-fine to coarse gneiss, used to some extent for railroad work and for ordinary building purposes. The quarry is located about 3 miles north of Friendship, a small station on the line of the Northwestern North Carolina railroad, so that the facilities for transportation are fair.

On the line of the North Carolina railroad, near Lexington, the granite has been quarried to some extent for railroad and local purposes; the material is fairly uniform and of medium-fine to coarse texture, and varies in color from gray to bluish-gray. The facilities for transportation at present are not good. There are other granite ledges in this vicinity, however, which are more accessible, and the facilities for quarrying are favorable.

At the shops of the North Carolina railroad, in Alamance county, granite is found which is above the average in quality both as to durability and the ease with which it can be worked. It is fine, even-grained, and light gray to gray in color. Though no very considerable opening has been made, there are indications of the existence of a considerable quantity of this stone in the vicinity. The stone is much used by residents of the vicinity, and is highly esteemed. Specimens of it may be seen in monuments and bases at Graham, North Carolina, and elsewhere.

Two miles north of the North Carolina Railroad shops the granite underlies a considerable extent of ground, and crops out in such a way as to indicate accessibility and ease of working. The outcrops on the hillsides are very favorably located for quarrying, and present an exception to the general rule in this vicinity, as the strata are not tilted. An examination of the specimens sent from this place by Professor Kerr indicates that the granite beds in this region underlying considerable depth of earth promise to afford a material much better in working qualities, as well as more even in structure, than that commonly found on the surface or at outcropping points.

At Louisburg, Franklin county, a medium-fine, uniform, gray granite is found. It was used in the construction of the jail at Louisburg. The rock comes to the surface in great masses, being bare for many rods and at several points in and near the town.

Four miles south of Salisbury, Rowan county, is found a medium-fine, uniform, gray granite. The rock crops out in a huge ledge called Dunn's mountain, in fact, it constitutes a range of high hills running northeast and southwest, and 300 or 400 feet above the surrounding country. On the summit of Dunn's mountain the rock projects above the surface in huge boulder-like masses from 15 to 20 feet high, some of them containing hundreds of tons. The process of quarrying is merely the splitting of these masses. Some of these blocks contain minute octohedral crystals of magnetite disseminated through the mass, which may be easily removed from a powdered specimen with a magnet. They do not affect the quality of a stone, and discolor it only for a short time on a dressed surface.

Near Henderson, Vance county, a gray, rather fine grained gneiss of very uniform texture is quarried, chiefly for railroad construction; it was employed in the construction of bridges over Haw and Deep rivers, the foundation of the post-office at Raleigh, and other structures. This material works well and easily, is comparatively hard, very durable, and is much used in the neighboring region.

Seven miles below Asheville, Buncombe county, a granite of fine and uniform texture is quarried for local purposes; it is a light gray in color, is easily wrought, splits readily into any regular form and size, and stone-cutters prefer it to any other rock in the region.

The gneiss near Jamestown, Guilford county, has been employed to some extent for railroad work and local purposes, and was used in the construction of bridge piers at Deep river, on the railroad. It is a fine, even-grained, gray gneissoid granite, and gives strong indications under the hammer of working unusually well. The nearest point on the railroad is 3 miles.

At Mount Airy, Surry county, the granite forms a ridge; it appears either at the surface or a few feet below, and outcrops at short intervals within a radius of  $2\frac{1}{2}$  miles of the place. One hill, within a mile of Mount Airy, 120 feet high shows an exposure of about 40 acres of this rock extending from its base to the top. The granite shows no jointage structure, and the hill is to all appearances an unbroken mass. The granite splits readily, is quarried and dressed with great facility in blocks of enormous size, and is of a durable character.

Four miles south of Winston, Forsyth county, the granite is a dark gray in color and splits readily into required shapes. The stone is quite uniform in texture and structure, though the amount of quartz contained varies somewhat in different parts of the quarry. This granite is durable and has been used for ordinary stone-work in the vicinity. It takes a fine polish and looks well when bush-hammered, but as yet there has been no demand for the material in fine construction. There is an inexhaustible supply, and blocks of any required size may be obtained.

Nine miles south of Salisbury, Rowan county, there is a homogeneous, durable, feldspathic granite of a pinkish color which is used for sills, steps, culverts, and like work. The ledge has an extensive surface exposure, and a jointage structure which aids materially in its working. The stone can be readily obtained in blocks of any required size.

Ten miles south of Salisbury a very hard, dark, granitic rock has been quarried chiefly for the rougher purposes of construction, such as streets, curbs, and door and window sills. It contains quite a large percentage of quartz, is compact and durable and is susceptible of good polish, although not so well adapted to ornamental work as are other rocks in the vicinity. There is a cap-rock 4 feet in thickness, which has been chiefly used, as it is apparently unaffected by the weather. This ledge presents several acres of surface exposure.

At Barringer's mill, Rowan county, a very hard quartzose granite, locally called "millstone grit", is considerably used for millstones, and to some extent as a building material. It is found in large exposures 12 miles north of Concord and 11 miles south of Salisbury. This stone is quite homogeneous and uniform as the outcrop is traced north and south from the quarry, and the supply is inexhaustible.

A fine, uniform, gray granite is found 6 miles northeast of Concord, Cabarrus county. On the Mount Pleasant road, in this county, the stone has an exposure where it has been blasted out in grading. It has an outcrop in two directions, that crossing the road having a general direction a little east of north, while the other has a general direction at right angles to this. The second outcrop can be traced for a quarter of a mile. This material, owing to its fine grain and compact structure, is susceptible of a good polish. It is of a light pink color and splits readily into regular shapes.

A coarse-grained porphyritic granite is quarried 3 miles north of Garibaldi, Gaston county, chiefly for trimmings, curbs, bases, and monuments, but it has also been used in great quantity for bridges and other building purposes. There are two outcrops in bluffs  $1\frac{1}{2}$  miles apart, both being very favorably located for quarrying. This is a good, durable granite, works easily, and is susceptible of a good polish. It can be obtained in blocks of any desired size.

At Gastonia, on the Dallas road, in Gaston county, a hard, fine-grained porphyritic granite is quarried to some extent for ordinary building purposes. The ledge forms a hill on the west side of Long creek,  $1\frac{1}{2}$  miles from the crossing of the Dallas and Gastonia road. It is hard, compact, takes a fine polish, is a durable stone, well adapted to all ordinary building purposes, and was used in the construction of the court-house in Dallas. Its highly porphyritic structure renders it somewhat difficult to give it a fine dressing, but it splits readily into regular shapes. The supply is inexhaustible, readily accessible, and blocks of any required size may be obtained.

One and a half miles northwest of Shelby, Cleaveland county, there is a fine hornblendic gneiss. It is a very handsome stone, splitting remarkably well in planes parallel to those of its lamination. This rock seems to harden on exposure. The outcrops and surface exposure extend half a mile in length. There is quite a large quantity of stone accessible, but the exposure most favorable for quarrying is in a bluff some 80 feet in height.

At the point where the Wilmington and Weldon railroad crosses Cotentney creek, in Wilson county, a red feldspathic granite, uniform in texture and structure, is found. It works easily, splitting readily, and takes a beautiful polish. This rock has not yet been quarried for general purposes, having only been used for the piers of bridges and other railroad structures. The rock is found outcropping on both sides of the creek, and is traced for a mile or more up stream. At George Barefoot's mills it crops out in a ledge 40 feet above the bed of the creek.

Two and a half miles north of Tosneot, on the Wilmington and Weldon railroad, in Edgecombe county, a dark gray, rather coarse porphyritic granite of excellent quality is quarried to a considerable extent for general building purposes. It is used chiefly by the Wilmington and Weldon railroad in the construction of bridges, culverts, etc., and there is a railroad into the quarry. The stone is much used in Wilmington for street curbing and general building purposes. It splits readily, but is quite hard. The outcrop can be traced for a quarter of a mile, and the rock can be had in any quantity. There is a quarry of stone differing a little from this in texture at Rocky Mount, 8 miles to the northwest of this point.

Ten miles east of Greensboro', on the line of the North Carolina railroad, in Guilford county, the granite is not now quarried except for occasional local purposes. The stone here is of rather variable quality, but good material was obtained for the large arched culvert over Rock creek, about a mile east of the quarry. The stone is of medium and coarse grain and of fair quality. The outcrop at various points in the neighborhood indicates that better openings than the one mentioned might be found near by, and that a well-developed quarry on this ledge would produce building stone of excellent quality as soon as the surface rock is removed.

The red granite 2 miles southwest of Hillsboro', Orange county, has as yet only been used by the North Carolina Railroad Company. It is a superior and beautiful building stone, and takes a fine polish.

The gneiss near Louisburg, Franklin county, is of a pinkish-gray color, fine in texture, and works well; there is an extensive surface exposure of the rock.

A compact, hard granite, coarse to medium in texture, is quarried locally for foundations at Cedar Rock, 9 miles east of Louisburg. The stone is found in a surface exposure of several acres, and the supply is inexhaustible. The top bed of rock is of a whitish color, while the bed immediately underlying it has a decided red tinge. The stone is very durable.

A fine-grained hornblendic gneiss is found 1 mile east of Henry's station, McDowell county. It has been used chiefly in railroad construction, and the quarry was quite extensively operated during the construction of the Western North Carolina railroad. The stone obtained from it is very compact and hard, and when polished presents a handsome appearance.

The gneiss  $2\frac{1}{2}$  miles west of Morganton, Burke county, is fine in texture and works readily, having quite a perfect cleavage in one direction. It outcrops in a bluff which gives a good quarry face.

The granite on the Carolina Central railroad, 3 miles west of Rockingham, Richmond county, is coarse and porphyritic in texture, and has a peculiar olive color unlike any other stone in the state. The rock projects above the surface in boulder-like masses from 10 to 15 feet high, and extends along the railroad for half a mile. Its principal use thus far has been in railroad construction.

The gneiss  $4\frac{1}{2}$  miles northwest of Hickory, on Catawba river, Caldwell county, is a handsome stone, but has as yet only been used for railroad work. It is easily quarried, and the facilities for transportation are good. The stone is fine and compact in texture, and stands exposure well. It has an outcrop in a bluff on the bank of the river which gives a quarry face some 75 feet in height.

A fine, compact, gray granite has been quarried for railroad bridges, and to a limited extent for other purposes of construction, 5 miles south of Statesville, at Poison Springs, a mile west of the Atlantic, Tennessee, and Ohio railroad, in Iredell county. It shows a good exposure and is easily worked. The strata in the quarry have a dip of  $20^\circ$  to the northeast and a strike northwest and southeast.

A mile southeast of Davidson College, in Mecklenburg county, a fine hornblendic granite of excellent quality for building purposes is found. There is but little stripping, and a large amount of good stone might be obtained near the surface.

A beautiful white feldspathic granite has been quarried for local purposes 5 miles southeast of Davidson College and 4 miles east of the Atlantic, Tennessee, and Ohio railroad, in Mecklenburg county. It is of a uniform,

rather coarse texture, and carries a large percentage of biotite, which gives it a spotted appearance. This stone has an extensive surface exposure of about half an acre. It is hard, but splits readily into regular shapes. The ledge has a dip to the northwest of  $15^{\circ}$ , and strikes northeast and southwest.

The granite at Mount Mourne, Iredell county, is of a coarse porphyritic texture, stands exposure well, and is suited for ordinary building purposes. There is an extensive surface exposure of the rock, and it can be had in any quantity. Although the texture is coarse, the stone is compact and takes a good polish.

A hard, dark-colored hornblendic granite of fine texture is quarried to a limited extent for building purposes, bridges, and culverts, 3 miles east of Mooresville, on the Atlantic, Tennessee, and Ohio railroad, in Iredell county. The rock carries some pyrite, but not enough to affect seriously its weathering qualities. The ledge has a strike north and south, which can be traced by a surface outcrop for three-quarters of a mile.

Three-quarters of a mile from Mooresville, Iredell county, are two varieties of quartzose gneiss, which have a well-marked line of contact. They are like in structure and composition, but differ remarkably in color. These stones work well and are durable. The outcrop occurs in the side of a hill, and can be traced for a quarter of a mile. The materials would take a good polish, and from their texture, composition, and color it may be inferred that they would be invaluable for ornamental as well as for general purposes. The direction of the outcrop is northeast and southwest, and there is a dip of  $10^{\circ}$  to the northwest.

At Warrenton, Warren county, a white porphyritic granite is much used for local building purposes, and was used in the construction of the jail. The stone stands exposure well; there is a large surface exposed, and the ledge is so situated that quarrying operations could be conducted with comparative ease.

Nine miles southwest of Warrenton there is a ledge of very pretty fine-grained, rather dark gray granite. It has been used locally for monuments, steps, posts, and work of that class. It is used in the construction of the "Annie Lee" monument.

At Northington ferry, 16 miles from Lockville, Harnett county, there are outcrops of fine schistose and slightly calcareous gneiss in the bluff of the river. The material splits very readily along the plane of lamination, but with difficulty in other directions.

A gray porphyritic granite has been quarried at Buckhorn falls, on the Cape Fear river, Harnett county, for the construction of canal locks and dams. There are good facilities for transportation by river and by railroad.

At Raleigh, Wake county, a quarry has been opened in a bare surface exposure and driven to a depth of 40 feet; it has been operated mainly to furnish material for the penitentiary building, but the stone is also used for culverts, flagging, and works of that class in Raleigh. It is a gneiss of fine to medium texture. At another quarry in the vicinity a fine-grained gray gneiss has been quarried for general building purposes for the last 75 years. It was used in the construction of the capitol and to some extent in the penitentiary buildings at Raleigh.

A short distance from the Carolina Central Railroad track, at Charlotte, Mecklenburg county, the leopardite porphyry is found—so called from the peculiar spotted appearance of the rock. It has been used locally for curbs, sills, steps, and other building purposes. There are few joints in the ledge, and blocks of any desired size may be obtained. The joints are so disposed as to give the natural blocks a rhomboidal shape. It takes a fine polish and is a beautiful ornamental stone, but difficult to work.

#### MARBLE AND LIMESTONE.

Professor Kerr forwarded specimens of marble and limestone, representing ledges of importance as sources of building material, from the following localities:  $3\frac{1}{2}$  miles northeast of Murphy, Cherokee county; Valley Town, 19 miles northeast of Murphy;  $1\frac{1}{2}$  miles from Red Marble gap, Macon county; Warm Springs, Madison county; and 10 miles north of Marion, McDowell county.

These marbles and limestones are of Archæan age, according to Professor Kerr, excepting the limestone at Warm Springs, which, he states, may be of later age.

Near Murphy two very distinct marbles outcrop together, one white, fine, and changing to somewhat darker color on exposure, while the other is quite dark and somewhat striped. The white rock is somewhat cut up by jointage, while the other has a massive structure and can be readily sawed into blocks of any shape and size. The stone has been worked to some extent, but never sufficiently to procure a good quarry face. The dark marble is close, compact, has a metallic ring, and takes a beautiful polish.

Nineteen miles northeast of Murphy there is a gray marble with white stripes, which is fine and compact in texture and polishes well. No quarrying has been done here, yet blocks of any size can be readily obtained. The strike of the strata is southwest and northeast, the dip  $80^{\circ}$  east. In the same vicinity a light gray marble of fine and compact texture, and susceptible of a fine polish, can be had in large quantity, having an extensive outcrop in two places; dip  $80^{\circ}$  east; strike, southwest and northeast.

At still another place in this vicinity two marbles are found outcropping together, one of a smoky-white color, and the other of a dark or variegated color; both are classed high as ornamental stones, and are susceptible of a fine finish.

One and one-half miles below Red Marble gap there is a marble which has a very extensive outcrop. It occurs in the side of the mountain in ledges 150 feet or more in height. In color it is varied, being of a flesh-color, striped with blue, yellow, or both. It is close, fine, and compact in texture, takes a beautiful polish, and can be obtained in blocks of any size. A railroad in course of construction will pass by the base of this cliff, and there is excellent water-power three-quarters of a mile below for sawing. The outcrops of these marbles are on the west bank of the Nantehala river for a distance of  $3\frac{1}{2}$  miles, and seem to overlie a coarse slate which dips  $60^\circ$  to the southeast. The direction of the strike of the strata is east by north.

Near Warm Springs, Madison county, the formation which Safford considers the Knox dolomite crosses the French Broad, rising in steep cliffs along the river on both sides to a height of 40 or 50 feet. It is limestone of a gray to light ash color, fine and uniform in texture. It has as yet been but little used, as the region is thinly settled, but it is a good material for ordinary building purposes.

The dolomitic limestone 10 miles north of Marion, McDowell county, has not as yet been much used for purposes of construction, but is well adapted for general building purposes and for ornamental work. The surface rock is much cut by a jointage, but as the stone outcrops in the side of a hill it is easy to reach a depth which will avoid this difficulty. It varies in color from steel-gray to white.

#### SOAP-STONE.

Specimens of talc or soap-stone representing ledges of importance were forwarded by Professor Kerr from the following points: 7 miles northeast of Murphy, Cherokee county;  $4\frac{1}{2}$  miles from Greensboro', Guilford county; Nantehala river, Cherokee county; from near the North Carolina Railroad shops, Alamance county; and from Deep river, Moore county.

It is all of Archæan age, according to Professor Kerr. It has been used to a limited extent for chimneys, fire-places, hearths, lining for furnaces, and cemetery work.

A pure talc is found on the Nantehala river 5 miles below the Red Marble gap, and again 6 miles east of Murphy, on the line of the Georgia and North Carolina railroad. At the last-named place the talc has an outcrop with white marble in a ledge of considerable extent.

At another point on the Nantehala river, in Cherokee county, there is a very pure talc, translucent, in thin plates, and has been much used as a white-earth. Thousands of tons have been hauled to the railroad and shipped to New York, ground and bolted. It is equal to the finest French chalk.

On the Deep river, in Moore county, the soap-stone is very fine grained pyrophyllite. The layers are usually less than a foot in thickness; it has been chiefly ground and bolted and used as a white-earth; much of it is also employed for lining furnaces and building hearths and furnaces. It is used locally and shipped to New York in large quantities.

The method of transportation is by boat 15 miles to the Cape Fear and Yadkin Valley railroad.

#### FLORIDA.

E. A. Smith, in the *American Journal of Science*, April, 1881, gives the following remarks concerning the geology of Florida:

Almost the whole state of Florida, including the middle and western parts of the peninsula, has for its underlying formation the white or orbitoides limestone of Vicksburg (Upper Eocene) age. This is bordered on the east by a stratum of Miocene limestone, and the edge of the whole peninsula, together with the southern part, including the everglades, is of post-Pliocene or recent formation. The keys are of this recent age, and the coral limestones, which have been much used there, are composed of fragments of the same animals as now live in the gulf. The Hawthorne stone is of Eocene age and contains bones, etc., that identify it. These Vicksburg limestones, more or less covered by beds of stratified pebbles, sand, clay, and marl, form the soil of the state.

The orbitoides (Upper Eocene) limestone is not quarried to any considerable extent owing to the small demand for stone of any kind, but it is locally used for chimneys and house pillars in towns in every section of the state; in Gainesville and neighborhood it is much used. This limestone is often simply a mass of shells, and sometimes orbitoides mantelli is the almost exclusive constituent. The Saint Augustine coquina, or shell-limestone, is used to some extent for local building purposes in Florida. A specimen forwarded to the National Museum, by C. M. Terry, was taken from the basement of a house, and was probably quarried a century or more ago. Other specimens recently taken from the quarry are in the collection, and by comparing the two it is seen that the coquina is a durable stone in the climate of Florida, though there is no doubt it would rapidly disintegrate in the more severe climate of the northern states. The quarries are not operated at present; they are located on Anastasia island, about 2 miles from Saint Augustine. The rock lies very near the surface none of the excavations are more than 6 or 8 feet deep. The stone can be cut with an ax, and is taken out in such shape and size as is required for building. The old city of San Augustine was built wholly of this rock; the quarries were evidently opened more than 200 years ago, as there are houses and broken sections of walls which are older than this. Fort Marion is built partly of coquina. This fort as it is at present dates from about the middle of the eighteenth century. There is a large number of houses in the city that were built one hundred years ago.

On entering a house built of the coquina a sense of dampness and a cool, moist, atmosphere is experienced. The rock seems to possess the capacity of receiving and holding the moisture of the atmosphere; for this reason, and because wood and bricks are cheaper, the coquina is not now extensively used for building stone.

There is another material near Saint Augustine which is called the "shell" sandstone; it is formed on the beaches there by the grinding up of the shells by the sand, which is more or less like that found on all our beaches, except that where this material is formed



the shells are more abundant. It is a recent formation and is hardened by the lime in the sea-water, which is doubtless derived from the shells. These shells are almost entirely bivalve or lamellibranchs, and perhaps a few gasteropods. Mr. Rathburn of the Smithsonian Institution says that almost all of them are lamellibranchs.

Another interesting example of this shell-limestone and the manner in which it is formed is given by Professor Hartt in a publication concerning a sandstone on the Brazilian coast, revised by Richard Rathburn, and published in the *American Naturalist* of June, 1879. It is shown that these reefs are composed of analogous material to the Florida coquina, though they contain more siliceous matter. The solidification is mostly confined to the zone which lies just above and below the level of low tide, and the solidified material rests upon an insecure foundation of loose material. The formation is accounted for in the following manner: The waters of the tropical seas are highly charged with calcium bicarbonates; as the tide rises this water is absorbed by the porous sand, and on the retreat of the tide the solution is concentrated by evaporation, aided by the intense heat of the sun, and the solution becomes saturated in the sand both above and below the level of low water. The consolidation is also aided by lime holding solutions which filter through these stones from the land. This hardening of the sandstone takes a long time, as is shown by the circumstance that these beaches which are in the process of formation or disintegration are not hardened.

At Key West coral limestone is quarried, and numerous public and private buildings are erected of it. There are no quarries now worked although the entire island is composed of it, and in fact the whole of southern Florida is a coral reef. This stone has thus far only been of importance for local use.

There are few stone quarries in the state of Florida. At Hawthorne Mr. C. A. Simmons has opened a quarry, the stone of which is said by the state chemist to consist almost entirely of silica, possibly containing 5 or 6 per cent. of lime, and of a quality for glass-making. It contains petrified bones, and the geological age of the formation is Upper Tertiary. The stone has been gotten out for chimneys, sugar furnaces, and millstones, and to a limited extent for building purposes, but has not been shipped, for lack of means of transportation, but chimneys in the neighborhood were built of it thirty years ago. The rock is very soft when first taken out of the earth, but hardens on exposure to the air and sun. The largest stone taken out was a cube with a 34-inch edge, but a cube two or three times that size might be taken. The supply of this material is reported as inexhaustible, and it is sold at the quarry for 28 cents per cubic foot. It can be cut with a hand-saw, and two men can cut out 1,500 bricks of a size 4 by 8 by 16 inches in a day, each piece being equal to eight ordinary bricks. A railroad will soon be built in the neighborhood.

## TENNESSEE.

[Compiled mainly from notes of Messrs. Cotton and Gattinger.]

The colored marbles of East Tennessee are widely known and quite extensively used in this country for ornamental purposes. There are several varieties of beautifully-variegated marbles here possessing superior qualities, the ease with which they are dressed giving them an advantage over the colored marbles found in the Lake Champlain region; though these harder marbles are better for tiling and for other uses where the material is subjected to abrasion. The East Tennessee marbles have been used for decorative work in some of the most important buildings in our own country, including the Capitol at Washington.

The following is a list of some of the buildings in which the marble from the quarry of Mr. E. D. Dougherty, near Mooresburg, Hawkins county, may be seen: United States Capitol, United States Treasury, Washington, District of Columbia; state-house, Columbia, South Carolina; Ninth National bank, Park National bank, Seamen's Savings bank, Cisco building, Grand Central hotel, New York city; residence of William G. Fargo, esq., Buffalo, New York; Lutheran church, southwest corner Broad and Arch streets, Second Presbyterian church, the marble residence of George W. Childs, esq., Schenck's building, and Guy's hotel, Philadelphia, Pennsylvania; First National bank, Chicago, Illinois; residence of Mrs. E. W. Boyle, and that of Mr. John M. Mueller, Cincinnati, Ohio. This quarry is the oldest in East Tennessee, having been opened for the purpose of getting ornamental stone for the Capitol building at Washington. The stone has not been used for general construction on account of the high price which it commands for ornamental work, the price per cubic foot at the nearest railroad station being from \$2 to \$3.

The marble from the quarry of the Knoxville Marble Company is used for both construction and ornamental purposes. This is the most extensive quarry in Tennessee, and the oldest one in the vicinity of Knoxville. It was opened by the United States government to get stone for the construction of the custom-house and post-office buildings at Knoxville, the stone for the outside of the superstructure being bush-hammered and the mantels and other ornamental pieces polished. The floor tiling is made of this stone and Maclure limestone. A considerable quantity of this marble was also used in the state capitol at Albany, New York. The quarry is located at the junction of the French Broad and Holston rivers, and the stone is carried by boat 4 miles to Knoxville. A bush-hammered surface of this marble has a nearly white color, which, on exposure, becomes still whiter. It is susceptible of being highly polished, and when so polished has a pink tinge and shows wavy, dark lines running through it. It is highly esteemed for mantels and table-tops, because it is not easily stained, and it is also quite largely used for cemetery work. Tombstones which have been exposed for thirty years do not show the slightest signs of disintegration or wear. The stone possesses sufficient strength for the heaviest structures.

Messrs. Frierson and Morgan operate two quarries within 2 miles of Knoxville, one of them producing a white marble and the other a pink material known as Knoxville marble. Analyses made of the white marble show it to be an almost pure carbonate of lime. Marble from this quarry was used in the construction of the custom-house at Memphis, and the shaft of the Lee monument at New Orleans is made of it. The amount of this marble which

may here be quarried is practically inexhaustible. The pink-marble quarry shows about the same characteristics as the quarry of the Knoxville Marble Company. The former is located on the northwest side and the latter on the southeast side of what is known as the Knoxville Marble basin. The limestone crops out on the west side of the pink-marble quarry of Messrs. Frierson and Morgan.

Near Chattanooga, Hamilton county, a bluish-black limestone of the Lower Silurian period is quarried for general building purposes, the stone being used chiefly in that city. The quarry is very favorably located for transportation, being on the bank of the river. The rock is broken up by joints, though blocks large enough for ordinary purposes of construction can be obtained. It dresses quite easily, making a cheap as well as durable building material.

The Cincinnati limestone of the Lower Silurian period is quarried for foundations and underpinnings in the vicinity of Nashville; this material is not of very good quality, but it is the most accessible to the Nashville market, and furnishes most of the stone for ordinary construction purposes in the city. The stratum of limestone quarried is only a few feet in thickness, and but a small portion of the stratum is available for building stone. At a quarry known as the Reservoir quarry, now operated by Messrs. Callahan and Welsh, is a layer about 20 feet below the surface and about 7 feet in thickness, which is considered the best of any found in the vicinity of Nashville, and is the stone most used for buildings in that city. Above this layer there are but from 2 to 5 feet in all of stone suitable for building. The waste material is used for macadamizing streets, and some of the limestone is suitable for burning. Most of the stone found in the vicinity of Nashville disintegrates rapidly when set on edge, and is therefore unfit for curbing; this rapid disintegration is also seen where the stone has been set on edge in buildings, but where it is laid on its natural bed it is quite durable; some stone suitable for curbing is, however, obtained from the quarry known as the College Hill and Vanderbilt.

## OHIO.

[Compiled mainly from notes of Professor Orton.]

### SANDSTONE.

**SUB-CARBONIFEROUS.**—Those rocks of the sub-Carboniferous period, called the Waverly group in the *Geological Survey of Ohio*, are the most important as to production of building stone in the geological scale of the state. The following shows the arrangement of this formation, according to Professor Orton:

1. Maxville limestone, in patches.
2. Logan group.
3. Cuyahoga shale.
4. Berea shale.
5. Berea grit.
6. Bedford shale.

No. 1 occurs but seldom. No. 2 consists of fine-grained sandstones overlying and alternating with massive conglomerates in central and southern Ohio. Its thickness is about 100 feet. The Waverly conglomerate is a member of this group. No. 3, about 300 feet in thickness, is a blue argillaceous shale in many parts of Ohio, but in many places contains scattered courses of sandstone of great value. In southern Ohio these are concentrated and become very valuable. No. 4 is from 10 to 30 feet in thickness and is the equivalent of the Waverly block shale of southern Ohio. No. 5 is the Berea grit, the great quarry rock of northern Ohio. It is from 10 to 75 feet in thickness and extends in a belt from Williamsfield, in the southeastern corner of Ashtabula county, westward into Erie county, and thence nearly directly southward in Adams county to the Ohio river. This stratum of sandstone, where it has its best development, consists of heavy sheets with often a course at the top of thin broken layers called shell-rock. However, in many localities these thin layers are unbroken, even, and compact, and are quarried extensively for sidewalk paving. No. 6 is from 10 to 100 feet in thickness, and furnishes no building stone except in Cuyahoga county.

The line of outcrop of the Berea grit across the state from north to south is very near the dividing line between the formations of the Carboniferous age on the east, where the building stone is almost exclusively sandstone, and the formations of Devonian and Silurian ages on the west, where it is almost exclusively limestone.

The Waverly group, with its well-marked alternations of shales and sandstones, enters the state from Pennsylvania in its northeastern corner. The northern line of outcrop of the Berea grit in Ashtabula and Trumbull counties is for the most part deeply drift-covered, and in places it has been cut out by valleys of erosion. From Parkman, in the southeast corner of Geauga county, it can be traced in an almost continuous line of outcrop around to the Ohio river. In Parkman township, as far as exposed, it lies in thin, ripple-marked sheets.

In Mesopotamia, Trumbull county, a quarry of some importance is worked by the Mesopotamia Freestone Company, one mile west of the town center. The stone is used for buildings, flagging, bridges, etc., in the immediate neighborhood, and is of excellent quality. The nearest railroad station is 7 miles away. This company has just taken the contract to furnish the trimmings for the blocks now building at Burton, Geauga county. From

this quarry the Berea grit passes northward, and its outcrop may be traced along the line between Geauga and Ashtabula counties to the southeast corner of Lake county, where it turns to the southwest and follows along the line between Lake and Geauga counties into Cuyahoga county.

The Berea grit is quarried at Windsor, in the southeast corner of Ashtabula county. This quarry marks the most northeasterly locality where the Berea grit has any special economic value as a building stone; though even here the stone is much inferior to that to be obtained over quite an extent of country from Berea, Cuyahoga county, westward to Berlin Heights, Erie county. The pyrites and protoxide of iron contained in the stone at Windsor produce bad discoloration on exposure to the weather. As a source of material for heavy masonry this locality is invaluable, as Ashtabula county has no other stone well adapted for this purpose, and the Windsor quarry has furnished a large amount of stone for heavy bridge construction on the railroads and highways in this county. The quarry is located about 6 miles from the nearest station, and has the same disadvantage as the Mesopotamia quarry for shipping stone.

The most important quarry operations in these counties are carried on in Howland township, 3 miles northeast of Warren, Trumbull county. This stone had been known for many years, and was worked in a small way before the present company began operations. The stone is adapted to the special use of flagging on account of the extreme regularity of its beds, its composition, its strength, and its durability. In evenness of bedding it is remarkable among the quarries of the county. Blocks 10 feet square and 1½ inches thick are extracted, which a straight-edge laid upon the surface would touch at every point. Slabs but 1 inch or 2 inches in thickness have such strength that they go without question into general use. Their fine-grained composition causes them to wear in a uniform manner, and they always give a good foothold. The only defect in the quarry is that the north and south joints do not run evenly; but, as these joints are so far distant from one another as to preclude the possibility of transportation of the included masses, this defect is of but little moment. In one case a single strip 150 feet long, 5 feet wide, and 3 inches thick was raised in the quarry. The layers, although so very closely packed together, are perfectly distinct, adhering to each other scarcely more than sawed planks in a pile.

All the townships in this neighborhood avail themselves of this extraordinary supply of flagging, and the town of Warren is said to be the best paved town in the state; Mahoning avenue may be mentioned as exhibiting on its western side some of the finest flagging that has ever been laid. It has been sent to distant cities in northern Ohio, western New York, and western Pennsylvania, and examples of it may be seen in Pittsburgh, Mansfield, Hornellsville, Akron, etc. It has been used for general building purposes to a limited extent.

The quarries are drained by ditches with a constant good fall. In the flagging deposit proper there are found from four to seven courses, varying from 1 inch to 6 inches in thickness, the 6-inch course being the best and highest priced. The same general character of the stone holds in the adjacent territory, but is subject to some variation of quality. It is of a light gray color, and is the geological equivalent of the stone which is extracted from the Portsmouth and Buena Vista quarries at the southern extremity of the formation on the Ohio river.

The Cuyahoga shales, in which the Austin flag-stones are found, occupy the highest position in the Waverly group in this county, and in the southwestern corner of the county the conglomerate of the Carboniferous formation makes its appearance in a ledge called the Braceville ridge, which rises to 100 feet above the flat surrounding country, and occupies a part of the four townships of Warren, Newton, Braceville, and Lordstown. It is almost entirely destitute of soil, and its prominent points are conspicuously grooved and striated by glaciers. This rock has been the dependence of several generations for building stone in the surrounding region, but no large quantity has ever been extracted at any one time.

Over a surrounding area of 75 square miles whatever stone is used for foundations, well stones, and bridge stones is mainly taken from this ridge. The quarry operations are mainly carried on in the way of "gouging"—that is, in extracting the stone wherever it can be obtained to the best advantage without reference to future quarry operations. Although no quarries are systematically worked, several are in readiness for operation at any time; and it is safe to say that, in the aggregate, \$1,000 worth of stone per year is extracted. The material is a strong and enduring sandstone, containing but few pebbles, and is of especial value since the flat country for many miles around is destitute of stone.

The Berea grit is quarried extensively at Newburgh and at Euclid, in Cuyahoga county. A quarry has been recently opened on the east side of the Cuyahoga river, near Independence, and the stone has also been quarried at East Cleveland. The smaller quarries have not been considered in the tables.

As a flagging material this stone is considered by many to have no equal in northern Ohio. It is now used almost exclusively for paving the sidewalks of Cleveland and in many other northern cities, especially in the state of Michigan. It is a fine-grained, compact sandstone of a very beautiful blue-gray color when first quarried, a circumstance which caused it to be extensively used for the trimmings of buildings, although its exposure to the weather has frequently modified its appearance. It is not considered safe to use this material for building purposes except for foundations and bridges, as it frequently contains iron sulphide, the oxidation of which produces stains; and when it has not this defect the color due to weathering is not so uniform when the face

of the rock is exposed in a wall as when the bed is exposed in a pavement. A greater amount of the sulphide of iron is contained in the stone at Newburgh than in that at Euclid; and it must be added that examples can be cited where the Euclid stone has presented an unmodified appearance after years of exposure in buildings.

The whole stratum of the rock at Euclid is about 20 feet in thickness, and the different sheets are from 2 to 4 feet thick. As a rule the stone is sawed into slabs.

The outcrop of the Berea grit comes from the northeast, and enters the county in Mayfield township. It has no special economic value in the northeastern part of the county, but near Chagrin Falls, in the southeastern part, it lies in thin sheets, and is quarried to some extent for flagging purposes. At Bedford it will not compare favorably with the stone from some of the other localities for purposes of building; but it is especially valuable for manufacturing into grindstones, which command a high price in market. That variety of stone which is applicable for grinding springs is especially in demand. The material is a rather coarse grained and homogeneous sandstone, filled with little brown spots of iron oxide. In some portions of the stratum lenticular nodules of this oxide occur from one inch to several inches in diameter, and render these portions worthless; but as they occur only at certain horizons they are easily separated from the better material.

At Independence a stone possessing more of the characteristics of the Amherst stone is quarried, especially applicable for the manufacture of grindstones, although it is used to a considerable extent as a building stone. The material has been used in the city hall and in some other buildings at Cleveland. These quarries are located in a bluff, the outcrop of stone being about 4 miles long and 1 mile wide, and usually covered by a drift deposit from 1 foot to 5 feet in depth, although in some localities the rock is quite bare.

The Berea grit is at this place only from 30 to 40 feet in thickness, and only the top 10 feet have been extensively quarried, as immediately below this there lies a stratum of worthless rock from 3 to 12 feet in thickness. Below this, good material for grindstones and building stones is obtained. This has been little quarried on account of the cost of drainage and that of removing the worthless rock referred to. Only large grindstones, which are best adapted for dry grinding, are manufactured from this material, and it is said that the stones do not glaze when used for this purpose.

The statistics in the tables scarcely give a correct idea of the magnitude of the industry at Independence, as the rock has been quarried in many localities in this bluff besides those now operated.

At East Cleveland the Berea grit becomes 60 feet in thickness; and although it does not possess all the desirable qualities of the Amherst and Independence stones, the Cleveland architects prefer it for foundations on account of its superior strength and its accessibility. It has not been used for any important superstructures in the city, the more excellent stone, before mentioned, being so readily supplied to this point.

The Brooklyn quarries, which are situated just to the south of Cleveland, produce a material which is of about the same quality as that found in the East Cleveland quarries, but the rock is more broken, and is used mostly for foundations and underpinnings. Its broken character allows it to be easily quarried, but large blocks are not so readily obtained.

The largest sandstone quarry in the county is situated in Berea, where an immense amount of material has been extracted for building purposes and for small grindstones. Nearly 40 acres of the Berea grit have here been quarried out to an average depth of about 40 feet. The stratum is from 65 to 75 feet in thickness, and has been quarried to the bottom in but few places. The individual sheets are from 2 inches to 10 feet in thickness, and usually are very even in their bedding. The rock all lies below drainage level and seems to have been but little, if at all, disturbed since its deposition. Joints very seldom occur. The stone is usually soft in the quarry and is very easily channeled. It is of a blue-gray color and a little darker as a rule than the Amherst "blue-stone". A larger portion of the formation here is of the so-called "split-rock" character than at any other locality where it has as yet been quarried, and this characteristic is also more perfectly developed here than anywhere else.

The material is not so applicable for the manufacture of large grindstones as is that obtained in Lorain county, or at Bedford and Independence in this county. Small grindstones can, however, be manufactured more cheaply at Berea, because the rock can be split into thin slabs of any desired thickness with little or no waste. The manufacture of whetstones is also quite extensive.

These quarries produce building stones of an excellent quality, although great care must be taken in the selection of the material, as some of it contains sulphide of iron in such amount as shortly to disfigure the surfaces, even discoloring a portion of the wall below it. The material is, however, carefully graded in such a manner as to distinguish the good from the bad stone. For bridge-building purposes the Berea stone is considered the best of the sandstones of northern Ohio, since it possesses greater strength. Tests made by J. B. and W. W. Cornell indicated that a 1½-inch cube would withstand a pressure of 15,400 pounds. The Berea stone has been extensively used throughout the whole country, and may be seen in the following: The Merchants' Bank of Canada building, Young Men's Christian Association buildings, and Montreal Telegraph buildings, Montreal, Canada; post-office building, Bank of Montreal building, and the Garland & Mutchinson building, Ottawa, Canada; post-office building, London, Canada; post-office building and Bank of Toronto building, Toronto, Canada; court-house building, Hamilton, Canada; Senator Fessenden's monument; Methodist Episcopal church, Brookline, Massachusetts; New York Clipper buildings, block corner Cliff and Fulton streets, a figure of Christ 10 feet high, and Church of the

Transfiguration, New York city; Berea hall, Brooklyn, New York; court-house, Camden, New Jersey; Normal school, Saint Agatha's church, and Saint Luke's Episcopal church, Philadelphia, Pennsylvania; United States custom-house and post-office, Dover, Delaware; Young Men's Christian Association buildings, Normal School buildings, and Traders National bank, Baltimore, Maryland; Baltimore and Potomac Railroad depot, *National Republican* newspaper building, British minister's residence, and Lewis Johnson & Co.'s Bank building, Washington city; court-house, Napoleon, Ohio; court-house, Marysville, Ohio; Exchange building, Bronson's block, and Madison hotel, Toledo, Ohio; court-house, Sidney, Ohio; Beckman's building, Cleveland, Ohio; court-house, Winchester, Indiana; court-house, Crawfordsville, Indiana; Masonic temple, Indianapolis, Indiana; court-house, Wabash, Indiana; court-house, Noblesville, Indiana; the Ogden block, Dickey block, and McCormick block, Chicago, Illinois; United States custom-house and post-office, Port Huron, Michigan; court-house, Menomonee, Wisconsin; asylum for the insane, Oshkosh, Wisconsin; Cleveland viaduct, representing bridges.

Three miles west of Berea a large quarry is worked, and in the immediate neighborhood three other quarries are situated, which have not been tabulated here because they produce but very little building stone, and the material is almost exclusively manufactured into heavy grindstones. The total value of the grindstones produced from the four quarries was over \$10,000 during the census year. Good building stone could not be advantageously extracted, as the rock is very much broken up. Never more than 12 and usually not more than 7 feet of the rock are quarried, for below this the rock is more broken, and is called "shell-rock". The waste products of the quarries are sold for a mere nominal price for foundations and underpinnings. As the rock lies above drainage it is a very desirable material for trimmings on account of the permanency of its color. The grindstones sell for a little above the average price.

Stone quarried at West View is considered equivalent to the Amherst stone.

In addition to the large quarries mentioned the Berea grit is quarried in a small way to satisfy the local demand. Cuyahoga county forms one of the most important quarry districts in the United States.

Extracting and dressing the Berea grit is the chief industry in Erie and Lorain counties. The material produced from this and the adjoining regions, under the name of the Amherst building stone, is the most highly esteemed of any in the state, and it has been extensively shipped to Canada. There are large areas of good stone near the surface, away from railroad transportation, which have not been opened. Quite a variety of stones, as regards structure, can be furnished from this formation, increasing the number of uses to which it may be applied.

The Amherst quarries in Lorain county are located in a series of ledges which were once the shore-cliffs of lake Erie. The elevated position of these stones is a very great advantage, since the light and uniform color seems due to the fact that this elevation produces a free drainage, and the stones have been traversed by atmospheric waters to such a degree that all processes of oxidation which are possible have been nearly completed. The elevation also facilitates the extraction. Spur-tracks from the Lake Shore and Michigan Southern railroad pass through most of these quarries and supply means of transportation, and the C. and E. V. railroad furnishes means of access to those quarries not in direct communication with the above road.

The Berea grit at Amherst, as well as elsewhere, varies considerably in character and solidity within limited distances, and the ledges in which the quarries are situated apparently represent the more massive portions of the stratum, which have resisted erosion and have hence been left in relief.

An idea of the arrangement of the strata in quarries can be obtained from the following section, which is exhibited in the quarry of L. Halderman & Sons, at Amherst:

	Feet.
Drift material .....	1 to 3
Worthless shell-rock .....	6 to 10
Soft rock, for grindstones only .....	12
Building stone .....	3
Bridge stone .....	2
Grindstone .....	2
Building stone or grindstone .....	10
Building stone .....	4 to 7
Building stone or grindstone .....	12

The floor of the quarry, moreover, consists of good stone, which has been drilled for 12 feet, indicating a still greater thickness of stone which could be extracted.

The other quarries of the region exhibit a similar diversity of material, although the arrangement is not often the same. As regards colors, the stones may be divided into two classes, called buff and blue. The buff stone (Plate E E) is above the line of perfect drainage, and, in the section above given, this extends as far down as the 2 feet of bridge stone, forming a total depth of 23 to 27 feet. In most of the Amherst quarries the relative amount of buff stone is greater.

As will be noted from this section, the different strata are not applicable alike to the same purposes, and the uses for which the different grades of material can be employed depend principally upon the texture and the

hardness of the stone. The softest and most uniform in texture is especially applicable for certain kinds of grinding, and is used for grindstones only, and the production of these forms an important part of the quarry industry. In its different varieties the material is applicable to all kinds of grinding, and stones made from it are not only sold throughout this country, but are exported to nearly all parts of the civilized world. Some of the finest-grained material is also used in the manufacture of whetstones. There are various points in the system of the Berea grit where the stone is adapted to this use, but such a manufacture is best carried on when joined with a large interest in quarrying, so that the small amount of suitable material can be selected; and thus it happens that only at Amherst and at Berea are whetstones manufactured in large quantities.

The stone which is especially applicable for purposes of construction is also variable. That which is of medium hardness and of uniform texture is used for building purposes or for grindstones; some is too hard or not sufficiently uniform in texture for grindstones, and is used for building purposes only; and the material sometimes found which is difficult to quarry and to dress is used for bridge-building purposes only.

As regards appearances there is much diversity in the material produced in this region. There are differences due to diversity of textures, of colors, and of methods of stratification, yet these are seldom recognized by the casual observer. Differences in color give rise to the terms "blue" and "buff" previously referred to, and differences in methods of stratification give rise to the terms "split-rock", "spider-web", and "liver-rock". The regularly and evenly stratified stone is classified as split-rock; that in which the stratification is irregular and marked by fine, transverse, and wavy lines is classified as spider-web; the homogeneous stone which exhibits little or no stratification is classified as liver-rock. These lines of stratification are frequently marked by the presence of black ingredients which are composed of mica and carbonaceous matter. As regards composition, these stones are mainly a siliceous sand; and analyses show that the dry material contains usually as much as 95 per cent. of silica, with a small amount of lime, magnesia, iron oxides, alumina, and alkalies. When first taken from the quarry it contains several per cent. of water, and as long as this is retained the stones cut easily; upon its loss they harden. Analyses made for the Clough and Columbia Stone Companies show that their stones contained respectively 5.83 per cent. and 7.75 per cent. of water when wet, and 3.39 and 4.28 per cent. of water when dry. The stone is extracted during only eight months of the year, since it is injured by being quarried in the winter and subjected to hard freezing while still containing this quarry water. The winter months are, therefore, occupied in stripping and channeling. The average thickness of this sandstone formation is more than 60 feet in these counties, and in many places, as, for instance, at the Brownhelm quarry, it is over 80 feet in thickness. An acre covered by stone only 50 feet in thickness would furnish over 2,000,000 cubic feet. Many very fine buildings, both in the United States and Canada, have been built of the so-called Amherst stone, among which may be mentioned the Canadian Parliament buildings, and most of the public buildings in Toronto; and there is no city in the Union in which stone is extensively used where examples cannot be found in which this stone is used for trimmings and ornamental work.

Near Peninsula, in the northern part of Summit county, on the west bank of the Cuyahoga river, is a valuable outcrop of the Berea grit which has been very extensively quarried in the past, and shipped by canal to Cleveland and thence by lake to various lake ports, principally to Buffalo, New York. The base of the Berea grit is here several feet above the canal. The stone is still shipped quite extensively by canal, and also by the Valley railroad. The principal market at present is Akron. About 16 feet of the upper portion of the stratum are used for general building purposes; below this is a 7-foot course, used principally for the manufacture of mill-stones, for hulling barley and other grains; below this, the bottom course, about 5 feet in thickness, is a rather hard material, used quite extensively for paving purposes. The cap-rock is here about 20 feet in thickness; below this the first 6-foot course of building stone contains more protoxide of iron than the Amherst buff, and has a darker color. The remaining portion of the stratum contains less iron, and much of it is almost white.

The Peninsula stone has the reputation of being exceedingly strong, but it is harder and less homogeneous than that from the Amherst quarries.

The Berea grit has two lines of outcrop in Summit county, one on each side of the Cuyahoga river. The one on the east side passes down to Northampton township, where the stratum lies below the drainage level and contains a considerable amount of soluble compounds of iron, and has a very perceptible odor of petroleum, so that the material is not suitable for building purposes. The stratum has not been quarried to the bottom in this locality, but only about 18 feet in depth. The sheets or layers, so far as quarried, vary in thickness from 6 inches to 6 feet. The blocks of stone are mostly sawed into slabs for sidewalk paving. Still farther south, on the west line of outcrop in the northern part of Portage township, a quarry has recently been opened for the purpose of supplying material for sidewalk paving, and some for steps, caps, sills, etc. This material is similar to that in the above quarry, except that so far as quarried it contains no perceptible traces of petroleum.

The exposed strata of rock in Huron county show evidence of great disturbances and displacement. Sharp synclinal and anticlinal axes are visible in the majority of these exposures, and are most conspicuous in the Berea grit.

In Mr. Perrin's quarry the stratum dips at an angle of nearly 45°. The sheets vary in thickness from 8 inches to 10 feet. This stone is used principally for bridges and foundations. The rock is quarried by first blasting out with powder large masses, which are afterward cut by means of wedges into the sizes required.



In Mr. Grannell's quarry the rock has been less disturbed and lies in nearly a horizontal position. The sheets here are not so heavy as in the above quarry, but the quality of the material is about the same. The layers vary from 1 inch to 5 feet in thickness, and those 6 inches and less in thickness are used principally for paving purposes. The thinner sheets are raised from their bed by means of wedges and bars.

Still farther south in this county, in Fairfield and Greenfield townships, the stratum of the Berea grit is made up almost entirely of thin sheets.

In a quarry in the latter township the sheets vary in thickness from 1 inch to 2 feet, the prevailing thickness being from 1 inch to 6 inches. The material is used almost exclusively for paving purposes, for which it is well adapted, being strong and durable, though much of it is deeply ripple-marked and does not make a smooth pavement.

The line of outcrop of the Berea grit formation is marked by a series of quarries which cross the eastern tier of townships in Crawford county. (a) The quarries in Polk township are at present of much less importance than those in Jackson township in the vicinity of Leesville. Quarries have been worked in this vicinity for thirty or forty years. The quarry of the Leesville Stone Company is located about one mile north of the railroad station, but a spur-track is now nearly completed from the main line of the railroad to the quarry. The material from this quarry has earned a good reputation, and the stone has been quite extensively extracted during the last few years. The rock lies below the level of perfect drainage, and in both color and texture it is similar in appearance to that quarried at Berea, but on exposure to the weather its color changes to light gray. Blocks of any desired dimensions may be obtained in this quarry, and the method of quarrying is the same as that employed in the Berea and Amherst quarries. The material is employed for all general building purposes, most extensively, however, for the construction of bridge abutments and piers. It finds its principal markets along the line of the Pittsburgh, Fort Wayne, and Chicago railroad, from Crestline westward into northern Indiana. This quarry is locally more important from the lack of building stone suitable for heavy masonry along this portion of the railroad. Other quarries less favorably located are worked, some with considerable variation in quality, but furnishing material for local use.

In Plymouth township, in the northwestern corner of Richland county, the Berea grit is quarried for the construction of foundations and bridge work in the vicinity of the quarries. Some flagging material is also obtained from the quarry of Mr. Bevier. The material developed in this locality is inferior in quality to the Leesville stone, and on exposure to the atmosphere it is more liable to suffer detrimental discolorations.

The Waverly conglomerate furnishes nearly all the stone for ordinary purposes of construction in the town of Mansfield. In one quarry about 60 feet of rock is exposed. It is considerably broken up; the upper 30 feet being in thin layers, and the lower 30 feet in layers from 1 foot to 6 feet in thickness. Much of this material is beautifully colored in wavy bands of black, yellow, red, and gray, and would make a very ornamental stone if it were not so soft and easily worn by abrasion. It has been used to some extent for purposes of ornamentation in the town of Mansfield. In some of the colored material the red predominates, and the stone is harder but less beautiful in appearance, but it does not exist in large quantities. In another quarry the material is less broken up, and is more uniform in quality, texture, and color.

The Waverly conglomerate in this locality is a coarse-grained sandstone, but rather finer than in most other localities where it is quarried. The light-red and gray-colored samples forwarded to the National Museum were found to be very good and safe stones to work. The dark-red colored specimen is rather coarse and loose in structure.

A section of the quarry of Mr. D. W. Zent, at Belleview, exhibits the following arrangement of strata: (a)

	Feet.
1. Earth .....	2 to 4
2. Coarse pebbles of drift .....	8 to 10
3. Sandstone in thin layers .....	15
4. Sandstone in massive layers .....	8
5. Sandstone in layers of 1 foot to 4 feet .....	15

There is but little variation in the character of the material except in color. The material has been used principally in the construction of railroad bridges on the Chicago branch of the Baltimore and Ohio railroad. Considerable of the material is used at Lexington, Ohio, and in the neighborhood of the quarry. Only a small amount of powder is used in the extraction of the stone, and the amount of production is controlled by the demand for stone by the Baltimore and Ohio Railroad Company. The layers of stone are from 6 inches to 6 feet in thickness, and open joints occur from 4 to 5 inches in width. About 60 feet of rock are exposed in the quarry at the present time, and the formation has not yet been quarried out to the bottom. The color of the layers near the top of the quarry is brownish; farther down some of the stone has a yellowish appearance, and at the bottom of the quarry is a layer of mottled or clouded stone, a blending of red and brown.

An abundance of stone of indifferent quality may be obtained in the vicinity of Wooster from the Waverly formation. A little north of the town a much-broken sandstone is quarried to some extent for the production of material for building foundations and cellar walls.

The most important quarry in this locality is in the Waverly conglomerate. In this quarry blocks of any desired dimensions may be obtained, and the stone is used principally for the construction of foundations and bridge work. At the joints the material shows a discoloration to a depth of about 1 inch due to weathering. A quality of material rather superior to the above is obtained from the Carboniferous or Sharon conglomerate in Chippewa township, in the northeastern part of the county.

In the quarry of the Walnut Grove Stone Company, operated here, large blocks are obtained for bridge-building purposes, and some of the material quarried is used for the construction of foundations. The principal markets for the material are at Orrville and Wooster, and some is transported to Akron, in Summit county. The material is a coarse-grained though quite firm and durable sand rock, very suitable for heavy masonry. At the natural joints in the quarry the material shows but little discoloration from the effects of weathering. The marketable material here comes almost to the surface; it is necessary to remove only about 3 feet of drift material before the marketable product is reached. The material is quite soft when first quarried but hardens upon losing the quarry water.

The stratum in which the quarries near Massillon, Stark county, are located, according to the concurrent testimony of all the geologists of the Second Pennsylvania geological survey, is the second or middle sandstone of the great Carboniferous conglomerate; it immediately overlies and often cuts out the lowest coal, known as the Sharon seam. Dr. J. S. Newberry, in the *Report on the Geological Survey of Ohio*, confirms the designation of Carboniferous conglomerate for the Sharon conglomerate which lies below the Sharon coal. The Massillon sandstone, in the quarries near the town of Massillon, is quarried by means of channeling and wedging. The courses vary in thickness from 2 to 8 feet, the lower courses being the thickest. The stratification is somewhat undulating, and the courses are not uniform in thickness. Blocks of stone of any desired dimensions may be obtained from any of the quarries devoted to the production of building stone. The entire thickness of the stratum is about 60 feet. This material is employed principally for general building purposes, but it is also manufactured into grindstones, chiefly for dry grinding. According to the testimony of Mr. J. P. Burton, of Massillon, the Massillon sandstone, when subjected to a temperature of 900° F., yet remains in perfect condition. He has used the material for many years in his furnace-stack at the Massillon blast-furnace; and the stone which stood the above test was taken from the quarries of Messrs. Warthorst & Co. and used for a hearth. The texture of the stone is not the same in all the quarries about Massillon, and the finest-grained material is obtained from Mr. John Paul's quarry, about 5 miles north of the town. The upper layers in this quarry are crushed for glass-sand and the lower layers for steel-sand, and but little of the material is used for purposes of construction. Powder is used for removing the cap-rock, which varies in the different quarries from 2 to 10 feet in depth, and for extracting the material for glass- and steel-sand.

All three horizons are worked for the Youngstown market. The Briar Hill and Bear Den quarries belong to the middle horizon, and those of Austintown to the highest. The ledges in this locality, as a rule, grade upward in fineness, and the upper stones give the best results when dressed. All of them are nearly pure siliceous, and the waste material of the Briar Hill quarry is all ground or crushed and sold to the steel works; much of it is adapted also to coarse-glass manufacture. The rock of the middle ledge is colored in bands and lines with iron peroxide, which robs it of beauty, but interferes in no way with its durability. In all northeastern Ohio there is no limit to the amount of strong, massive, and durable building stone to be obtained. The quarries in the middle division of the conglomerate series, on account of the more favorable situation of the outcrops, are more largely worked than the quarries in the upper and lower divisions.

The Austintown quarries have been worked at intervals since the country was settled. The stone is light-brown in color, rather coarse, but uniform in texture. It is used to some extent for purposes of ornamentation in Youngstown, but its principal uses are for general building purposes and bridge work. Flag-stones of fair quality are also quarried here for the local demand, from a horizon just below the sandstone ledge. Blocks of any desired dimensions may be obtained from the middle division of this series, and the material is used principally for general building purposes, bridge work, and to a small extent for ornamental fronts. The principal market for all these quarries is Youngstown. Some material is shipped from the Briar Hill quarry to Pittsburgh and some is used for purposes of construction by the New York, Pennsylvania, and Ohio railroad.

Stone for local uses may be obtained almost everywhere in Tuscarawas, Holmes, and Knox counties, and for this reason no extensive quarry is worked. A quarry was opened and developed for the purpose of extracting material for bridge construction on the line of railroad running near the quarry, but is now nearly abandoned, because this railroad obtains building stone in cuts through the same stratum. This stone lacks the uniformity of texture and color demanded for the better class of work.

There are a number of ledges of sandstone, about 20 feet in thickness, found at different horizons in the Lower Coal Measures in Tuscarawas county, and they all furnish some building stone. A considerable portion of the building stone used in the county is obtained from masses of rock which have been detached from the solid ledges.

The stone from the quarry of the Tuscarawas Valley Coal and Iron Company is finer in texture and of a more uniform color than any other stone obtained in the county. It is used for "bottom" in the blast-furnace belonging to this company, and resists the action of heat uncommonly well. The principal uses of the material from these quarries are for constructions of foundations, underpinnings, and bridges in the vicinity in which the quarries are located.

Almost everywhere in Holmes county there are lying on the surface large masses of rock which have been detached from the strata of the Coal-Measure sandstones. These detached masses supply the local demands for building stone, and no quarries are developed in the ledges.

Near the central part of Knox county, from 3 to 7 miles northeast of Mount Vernon, large masses of rock lie loose upon the surface. These have not been transported to their present station, but have been left in loose blocks on the surface by the undermining and removal of a portion of the soft shales that immediately underlie the stratum of sandstone. The quarry operations represented by Messrs. Bartlett Brothers are worked in these masses of sand-rock. This stone is considered the best material for building purposes to be found in the vicinity of Mount Vernon. It is used for all general building purposes, including caps, sills, columns, etc., in the town and through the neighboring country. It is estimated that about 250,000 cubic feet may be obtained in some places from the surface of half an acre in area. This material has been a source of local supply for about seventy years.

The Waverly conglomerate, which is quarried near Howard station, is not so highly esteemed as is the stone of the Carboniferous conglomerate, described above. The demand for it is principally for use in the construction of railroad bridges, arches, culverts, and to some extent for foundations and underpinnings. Some is shipped to Columbus, Ohio. The layers of stone in this quarry vary in thickness from 6 inches to 6 feet, and blocks of any required dimensions may be obtained. It is rather soft when first extracted, but hardens on exposure to the weather.

In Morrow county the Berea grit crops out, and is quarried in North Bloomfield, Washington, Gilead, and Lincoln townships. Its total thickness varies from 15 to 40 feet in different localities. The thin layers of its upper portion are very even and compact, and make an excellent flagging material. The most favorable development of the flag-stone occurs near Iberia. At this place the layers vary in thickness from 1 inch to 6 inches, but 2½ inches is the most common thickness; the total depth of flag-stone is about 20 feet, below which from 18 to 22 feet of heavier layers occur. The quarries are located in the bed of a stream, and only the thin layers are extracted. The amount of flag-stone that may be quarried in this vicinity is practically inexhaustible. At present the material is carried on wagons 2 miles to the nearest railway shipping-point, and a considerable portion of the product of the quarries is carried on wagons to the town of Galion, in Crawford county, which is the principal market for the stone quarried in the northern part of Morrow county.

The thickness of the heaviest layers in the county is only about 2½ feet.

The Berea grit crosses the eastern part of Delaware county, and at Sunbury quite important quarries have been developed. It has here been worked to the depth of about 20 feet, as deep as natural drainage is available. Good building stone might be obtained below this depth, but artificial drainage would be required. Plate F F represents a surface of the Sunbury freestone. This material bears a close resemblance to the Euclid "blue-stone" of northern Ohio. The layers vary in thickness from 3 inches to 3 feet. The thin layers are quarried for flagging stones, and the heavy ones for general building purposes and to some extent for ornamental work. The material finds its principal markets at Delaware, Mount Vernon, Columbus, and Orrville, Ohio. Examples of it may be seen in the building of the Ohio Industrial Home for Girls in Delaware county, and in the National Bank building at Delaware.

The sandstone of the Berea grit in the eastern part of Franklin county has considerable local value, because on each side of its outcrop the surface of the country is occupied by a belt of shale from 8 to 10 miles in width, the belt on the west being entirely destitute of building stone and the one on the east is nearly so. The formation has, however, in this part of the state lost many of the valuable qualities which characterize it in Erie, Lorain, and Cuyahoga counties. On account of its accessibility, however, it has been used quite extensively in Columbus, the Ohio Institution for the Blind being constructed of it as well as several stone fronts.

The entire product of a quarry 10 miles east of Columbus is sawed at the quarry for caps, sills, ashlar, etc., and shipped to various points along the lines of the Baltimore and Ohio and Pan-Handle railroads, but principally to Columbus.

The greater portion of the surface of Licking county is occupied by the rocks of the Waverly formation, but a portion of the eastern part of the county is occupied by the conglomerate and Coal-Measure rocks. The Waverly conglomerate crops out in bold cliffs over quite an extensive area in Madison and Hanover townships. It has been quite extensively quarried in this vicinity for use as material for construction on the lines of railroad running through this section of the county. It is a rather coarse-grained sandstone, in some localities quite uniform in texture, and in others containing pebbles sometimes an inch in diameter. It is rather soft when first quarried, and works rather easily, but hardens on exposure. In some places sections of this conglomerate 100 feet in thickness are exposed in ravines. The quarries now operated are located in the banks on each side of the Licking river. One quarry is located in the north bank, at the foot of which runs the Ohio canal, which furnishes the means for transporting the material to Newark and Columbus, where it finds its principal markets. Another quarry is located in the south

bank, at the foot of which passes the Baltimore and Ohio railroad. The material is used quite largely for heavy masonry along the lines of railroad, and for general building purposes at Newark and Columbus. It varies in color from gray to light brown. The cap-rock necessary to be removed seldom exceeds 4 feet in depth, and consists principally of soil, loose sand, and gravel.

This material may be obtained with equal advantage on the line of the Pan-Handle railroad, and there is no limit to the amount of strong and durable sandstone which may be extracted in this vicinity. A quarry  $1\frac{1}{2}$  miles south of Newark, in the Cuyahoga shale, furnishes a fine-grained and homogeneous material, at present used principally for foundations at Newark and Columbus, Ohio. Trinity church, at the latter place, was constructed of this material, and the only defect noticed in the stone is the discoloration. It gives evidence of both strength and durability when laid on its natural bed, and when it is quarried sufficiently early in the season to allow it to become thoroughly dry before being subjected to the action of frost.

The Waverly sandstone seen in Fairfield county in the cliffs along the Hocking river is generally coarse-grained, often passing into a true conglomerate; and it shows the same character in the hills and highlands west of the river. It is more commonly of a rich yellow color, but sometimes of a darkish brown. In many places the stone is firm in texture and capable of resisting great pressure without crushing. (a) The stratum in which the quarries near Lancaster are worked is solid, and about 30 feet in thickness. There are but few joints, and the largest sized blocks may be obtained. The material is used principally for bridge construction, canal locks, and general building purposes. The principal markets for this material are Columbus, Centerville, and Lancaster, Ohio. The material for the superstructure of the Saint Joseph's cathedral at Columbus was obtained from the quarry of Messrs. Sharp & Crook, and that for the foundation of the same structure from quarries in the Waverly conglomerate near Hanover, Licking county. The amount of cap-rock to be removed is from 3 to 4 feet in some localities, and as much as 25 feet in depth in other places. Powder is employed in quarrying.

The Lithopolis quarries are located in the lower portion of the Cuyahoga shale of the Waverly group. There are several horizons of building stone in the Waverly group, but this particular portion of the Cuyahoga shale is quite rich in quarries, especially in southern Ohio. There is a number of important quarries in the upper member in different parts of the state, as indicated in the tables. The lower portion of the Cuyahoga shale has no economic importance in the northern part of the state. The only important quarry in the whole formation in northern Ohio is that of the Austin Flag-stone Company, in the upper portion of the shale. In southern Ohio the most important building-stone quarries are in the lower portion of this shale.

The stone quarried at Lithopolis and at other localities at or near the same horizon is commonly denominated freestone. It is a fine-grained sandstone, usually in quite thin courses; is sawed easily, and answers a very convenient purpose for caps, sills, and stone fronts. Columbus, Ohio, is the principal market for the product of the quarries.

Stone for the ordinary purposes of construction may be obtained in various localities in Hocking county, but only one quarry is developed in the Waverly conglomerate near Logan, and the material from this has but recently come into the market through the facilities for transportation afforded by the construction of the Hocking Valley railroad. There are no important quarries below this point in the Hocking valley. The stratum of the Waverly conglomerate in this locality consists of three layers, each about 10 feet in thickness. The rock underlies an area of four or five acres with a cap-rock but a few feet in depth, consisting of clay and gravel, which is easily removed. The quarry is located close to the railroad and is capable of supplying any demand for material likely to be made upon it. It finds its principal markets at Columbus, Lancaster, and London, Ohio, and has been shipped to some extent to Marion and Winnemac, Indiana.

When a canal was constructed through the valley fifty years ago, it furnished easy transportation for the great ledges of sandstone that bound the valley for a dozen or more miles, and the stone from Waverly, Pike county, soon became famous in Columbus and central Ohio generally as Waverly stone. The name was early extended to a great group of associated sandstone and shales of sub-Carboniferous age, as has recently been proved, but the real age was long an unsettled question; hence comes the Waverly group of Ohio geology. It is the first sandstone, except the local Euclid blue-stone, reached in ascending the geological scale of Ohio that can be quarried. The stratum is best shown from Waverly south for 10 or 12 miles. It dips below drainage just south of the county line on the river's bed. For these 10 or 12 miles it is reached on all the ravines on each side of the river. The stone about Waverly has been followed back under such heavy cover that the increased expense of quarrying has ruled the material out of the market. A quarry, at Piketon has just been made possible by the Scioto Valley railroad, constructed four years ago. There is, however, no first-class stone now available in this quarry. There are 26 feet exposed in it in courses varying from  $1\frac{1}{2}$  to 24 inches in thickness. There is a great amount of reliable stone in the stratum and a great amount that is treacherous. It is by no means equal in uniformity of quality to the Berea stone of northern Ohio. It formerly furnished a grindstone grit of great local value. The stone is always ripple-marked and bears other evidences of having been formed on a shore-line. It is usually of a uniform gray color, but there is also a variegated variety clouded with red which is one of the most striking stones of the state.

The above, however, is but an inadequate statement in regard to the range of quarries that for many years held the first place in southern Ohio. Many other ledges of at least equal value have now been rendered available by the new lines of railroad communication.

The Waverly stone, where it has not been subjected to atmospheric influences, has the characteristic bluish-gray color of the Berea grit formation in other parts of the state. The difference in composition between the weathered portion and the blue-stone is shown in the following analysis made by Professor Wormley for the *Report on the Geological Survey of Ohio*:

	No. 1 (white-stone).	No. 2 (blue-stone).
	<i>Per cent.</i>	<i>Per cent.</i>
Silicic acid.....	91.30	91.00
Protoxide of iron.....	0.86	1.17
Sesquioxide of iron.....	0.06	0.80
Alumina.....	5.79	5.20
Lime.....	Trace.	Trace.
Magnesia.....	0.32	0.28
Water, combined.....	1.80	1.80
Total.....	99.63	99.75

Near Cynthiana, where the variegated variety above referred to occurs, there is also found a very white, fine-grained variety, and the following analysis shows this to be very nearly of the same composition as that above, without the oxides of iron:

	<i>Per cent.</i>
Silicic acid.....	91.35
Iron, sesquioxide.....	Trace.
Alumina.....	6.00
Lime, carbonate.....	0.75
Magnesia, carbonate.....	0.34
Water, combined.....	1.00
Total.....	<u>a 99.44</u>

The Waverly brownstone quarries lie at a horizon about 40 or 50 feet above the Waverly stone, or Berea grit, in its southward extension. They lie very near the horizon of the famous Buena Vista stone of Scioto county. A number of the best stone fronts at Columbus, Ohio, have been constructed from the product of these quarries. The stone is brown only on the outcrop; when found a few feet under cover it assumes a dark blue color and loses its value as an ornamental stone. The blue variety contains a large amount of soluble iron protoxide which produces a bad discoloration on exposure to the atmosphere. The following analysis made by Professor Wormley for the *Report on the Geological Survey of Ohio* shows the composition of the Waverly brownstone:

	<i>Per cent.</i>
Silicic acid.....	73.90
Protoxide of iron.....	.....
Sesquioxide of iron.....	13.44
Alumina.....	8.56
Lime.....	Trace.
Magnesia.....	0.46
Water, combined.....	3.30
Total.....	<u>99.66</u>

The quarry which has been the most important is located about half way between Waverly and Piketon. Here the stone forms a massive bed 8 feet in thickness. The same ledge has been worked along the valley on both sides of the Scioto river for 10 or 12 miles. That quality of stone still remains in easy reach, though some of the quarries have already yielded all their brownstone to the market. The depth of cap-rock to be removed in these quarries nowhere exceeds 15 feet.

All the ravines that reach the Ohio valley below Portsmouth for 20 miles disclose a large amount of excellent building stone, but in the ravines that are found from 2 to 4 miles below there is a horizon disclosed that lies low enough to be easily reached, and that is naturally covered by an easily-eroded cap, so that a very considerable amount of building stone has been found readily accessible. This horizon is at about the middle of the sub-Carboniferous system in Ohio.

The Portsmouth quarries have been worked since the first settlement of the Ohio valley. During the last fifty or sixty years a great number of separate quarries have been opened, but all on the same horizon. When the stripping becomes heavy a slight change in location is made. The land is considered of no great value for any other than quarrying purposes. Some locations prove better than others, and these are being worked more systematically of late years.

At the quarry of Messrs. Reitz & Co. the stone occurs in layers from 6 to 24 inches in thickness. These courses are frequently separated by an inch or two of shale. Joints do not occur frequently to interfere with the systematic working of the quarries. For flagging the stone is unequaled in the Ohio valley, as it wears evenly, always gives foothold, and is in every way satisfactory. It is well adapted to sawing, and is used quite extensively for general building purposes. The material finds its principal markets along the Ohio valley, through Ohio, West Virginia, Kentucky, and Pennsylvania. It has been used in the construction of the court-house at Athens and the Children's Home building at Gallipolis, Ohio, and the Western penitentiary of Pennsylvania, at Allegheny.

The quarry of Mr. J. M. Inskeep is located about 12 miles below Portsmouth, on the Ohio river, at a horizon about 60 feet above the Buena Vista stone proper. There are 30 feet of rock in about 20 different layers. The lowest course, about 32 inches in thickness, is the most valuable stone. This course is covered by 4 feet of blue shale, which is the largest mass of shale in this section. The other shale deposits are but little more than partings between layers of sandstone. The courses are remarkably even in thickness, but those above the lowest do not yield a strictly first-class material. For the last three or four years this quarry has supplied material quite extensively for the Columbus market, and a number of fine stone fronts have been constructed from it. The stone varies considerably in quality, and needs to be carefully inspected.

The southwestern portion of Scioto county and the southeastern corner of Adams county, two adjoining districts, were once the most important localities in Ohio for the production of building stone. In the earlier days of the state an engineer of reputation, employed upon the construction of canals, became conversant with the then known building stones of the state, and recognizing the great value and accessibility of the ledge, commonly known as the Buena Vista Freestone ledge, bought a large territory here, and began the development of the quarries in a large way. Other horizons of good rock were found at various levels, but this one bed, by its color and quality, supplied the Cincinnati market almost exclusively. Its reputation spread throughout the whole Ohio valley and beyond. Large quarries were opened on both sides of the river, government patronage was secured, and material for the construction of custom-houses and other public buildings was ordered from the Buena Vista quarries. So great was the demand for this stone that material of poor quality as well as of good was hurried into the market. The greenstone while full of quarry water was laid in massive walls, and the bad behavior of this material soon excluded the stone almost entirely from the market. It is, however, as good now as when it earned its high reputation, but needs careful and conscientious selection and suitable seasoning.

Just below the horizon of the Buena Vista stone lies the Berea shale, a bed of highly bituminous and very fossiliferous black shale, ranging from 15 to 30 feet in thickness. Its bituminous composition makes it a source of petroleum, which rises into the sandstone courses that lie above it. This is the source of one of the worst impurities of the Buena Vista stone. When followed under cover it is found loaded with petroleum or with tar, which seems not only to disfigure the stone but to weaken it to some extent; and other impurities in the stone are masked for the time by this bituminous matter. The oil-bearing stone is tolerated only in rough, heavy work. Some of the stone contains sulphide of iron, which, on exposure to the weather, becomes oxidized to the sulphate and goes into combination with compounds of aluminium, and appears on the surface of the stone as a white efflorescence which has the characteristic taste of alum. Grains and nuggets of pyrites appear in the shales associated with this sandstone, but are not very perfectly visible to the naked eye in the city ledge (the name now applied to the stratum proper of Buena Vista stone). The rock is quarried by channeling and wedging in the same manner as in the quarries of the Berea grit in northern Ohio. No stone is extracted for the market during the winter months, but this time is occupied in removing the cap-rock and in channeling. The behavior of the material when properly selected is apparent in a number of important structures in Cincinnati, and that of the unselected material may be seen in the custom-house and other buildings in Chicago. The material has also been used with good and bad results in a number of other cities and towns, including Louisville, Kentucky, Pittsburgh, Pennsylvania, and Detroit, Michigan.

**CARBONIFEROUS.**—The Carboniferous conglomerate (Sharon conglomerate of the *Second Geological Survey of Pennsylvania*) furnishes the only important building stone in Portage county. This formation in Ohio geology is commonly called "the Conglomerate".

In Franklin, Mantua, and Nelson townships, where it is well seen, it is a coarse, drab-colored sandstone, in places thick set with quartz pebbles from the size of a pea to that of an egg. It is quarried in these localities to a small extent for local purposes.

At the quarry of Messrs. Case & King, in Windham township, it is finer, whiter, and more homogeneous, and answers quite well for architectural purposes. It is rather too coarse for fine work, but it is strong and durable and well adapted to bridge building and all other plain and massive masonry.

In Summit county the Carboniferous conglomerate underlies all the higher portions of the county and forms the surface rock over all the middle portion, except where cut through by the Cuyahoga and its tributaries; though generally covered and concealed by beds of drift, it is exposed and quarried in all the towns north of Akron. In the valley of the Cuyahoga it forms cliffs sometimes 100 feet in perpendicular height. The rock is about 100 feet



in thickness, generally a coarse-grained, light drab sandstone, but in some localities, and especially near the base of the formation, becoming a mass of quartz pebbles, with just enough cement to hold them together. (a)

All the accessible material that is now known in this formation is applicable to ordinary purposes of building. Although it is quarried in many different localities for local supply, it is worked extensively in but two localities—at Akron and in Twinsburg township. The quarries at Akron are worked principally to supply the town with foundation stone and the immediate vicinity with bridge stone. The quarries in Twinsburg township are at present worked quite extensively to supply material for the construction of bridges on the Cleveland and Pittsburgh and the Connotton Valley railroads.

A section in Mr. Parmelee's quarry exhibits 18 inches of soil and gravel, 15 feet of coarse sandstone in which thin strata of pebbles occur from  $1\frac{1}{2}$  to 4 feet apart, and 6 feet of very coarse conglomerate underlain by shale. The 15-foot course of sandstone occurs in a solid mass, which separates easily where strata or sheets of pebbles called "bed-seams" occur. In the Akron quarries the stone is fine-grained and more homogeneous than in the Twinsburg quarries. In Mr. Hugill's quarry the rock has been quarried to a depth of 40 feet, and the material obtained is a coarse-grained sandstone free from pebbles. Formerly, in a quarry known as Wolf's quarry, near Akron, a local stratum produced a deep reddish purple sandstone, perhaps the most beautiful building stone ever produced in the state, which was used quite extensively in Cleveland, and two residences on Euclid avenue are constructed of this material. At Cuyahoga Falls a similar material has been quarried to some extent for the construction of buildings in the town. The quantity of this variety of building stone is apparently not large, and it seems that it is nowhere known at present where it can be profitably quarried in a large way. The Wolf quarry has not been worked for a number of years.

The stone quarried for building purposes in Coshocton county is obtained from blocks detached from strata of sandstones of the Lower Coal Measures. The stratum from which the blocks quarried by the parties represented in the tables have been detached is a solid ledge 30 feet in thickness, and lies a few feet above the horizon of the Zoar limestone. The material is usually a light-colored sandstone, though some of it has a reddish color, and some is a finer-grained white sandstone. The stone used for the construction of locks on the Ohio canal, through Coshocton county, was obtained from these quarries. The stone has the reputation of enduring well ordinary atmospheric influences, but not of withstanding a high degree of heat. It is principally used for bridge building and foundations in the vicinity of the quarries.

Material for ordinary purposes of construction is obtained in various localities in Muskingum county from the Coal-Measure sandstones, but there is no extensive quarry at any place except about half a mile east of Zanesville. This quarry furnishes by far the largest part of the stone used for construction in and about Zanesville. It has been used quite extensively for building canal locks, foundations, and for sidewalk pavements. Some of the oldest buildings in Zanesville are constructed entirely of this material, and it is found that the stone is more capable of resisting atmospheric agencies than of resisting the abrasive action to which it is subjected in sidewalks. This material is easily obtained in great abundance and of fair quality, and is the most important among the building stones found in the neighborhood of Zanesville, except perhaps the sub-Carboniferous limestone with which it has been recently brought into competition.

The most important building-stone quarry in Noble and Guernsey counties is near Cumberland, on the line between the two counties. The stratum quarried is solid and about 10 feet in thickness. The material is a dense fine-grained sandstone, rather hard, but susceptible of being finely carved. It is of a gray or light-brown color where it has been subjected to atmospheric influences, but as the excavation progresses into the hill a material of a bluish-gray color is obtained. Joints in this stratum are filled up with a hard calcareous matter deposited from solutions of the material from a limestone ledge a short distance above the sandstone. The size of blocks determined by these joints is about 30 by 15 by 10 feet. The material is employed for all general building purposes, principally at Cambridge. It is used in the superstructure of the court-house in process of construction at this place. The foundation stone for this building was obtained near Cambridge, from a quarry worked only to supply temporary demands.

Stone for the ordinary purposes of construction may be obtained in various localities in Jefferson county from the different sandstone strata of the Coal Measures, which occupy the whole area of the county; but the only quarries that have been developed are those near Steubenville, in the Upper Coal Measures.

One quarry furnishes stone for general building and paving purposes, used principally in the town of Steubenville. The material has a bluish color where it has not been exposed to atmospheric action, and at the natural joints discoloration has penetrated into the rock from 10 to 18 inches. This liability to discoloration makes this stone unfit for the finer purposes of construction.

A better material for purposes of ornamentation is obtained from the quarry where two separate and distinct strata of sandstone in the Upper Coal Measures occur. There are, in reality, two separate quarries, located at different heights, at the side of a hill west of Steubenville, near the Ohio river. The material from these quarries is used largely for cemetery work, bases of monuments and tombstones, vaults, etc. That from the upper quarry

is better adapted to fine work, but it is not so extensively used, because the material is not as accessible as that in the lower quarry. The Episcopal church at Steubenville was constructed of stone from these quarries.

Belmont county is well supplied with material for the ordinary purposes of construction from the sandstones of the Upper Coal Measures and the Lower Barren Measures; and some of the quarries furnish material quite well adapted for ornamentatal purposes. The most important quarries are those in the eastern part of the county, near Martin's Ferry and near Bellaire. These quarries are located in the hills several hundred feet above the Ohio river. The quarry of Mr. Charles Siebrecht is located about 100 feet high in one of these hills. The stratum is a solid mass about 30 feet in thickness. The material is used for general building purposes, principally at Martin's Ferry. The stone-work of the suspension bridge across the Ohio river at Wheeling, West Virginia, is constructed from this material.

The total thickness of the sandstone ledge quarried by Mr. Robinson, near Bellaire, is about 40 feet. The rock, for a depth of 17 feet from the top, is very uniform in texture and general appearance. The portion of the ledge below this is in irregular masses, unfit for building purposes, and is locally called "nigger-head". The layers of stone in the upper 17 feet are quarried for building purposes, and vary in thickness from 4 to 7 feet. This is esteemed as the best material for building purposes found in Belmont county. The arches and abutments of the Baltimore and Ohio Railroad bridge across the Ohio river at Bellaire, and of a number of other bridges on the same railroad, are constructed of this stone. The material finds its principal markets at Bellaire, Ohio, and at Wheeling and Benwood, West Virginia. Traces of coal vegetation are found occasionally between the layers of stone in this quarry. A short distance above this sandstone a vein of coal occurs, and above this a limestone stratum 20 feet in thickness, quarried for furnace flux.

The ledge of rock in Mr. Hutchinson's quarry is about 30 feet in thickness, and is considerably broken into irregular masses. The stone is fine-grained, rather hard, and difficult to cleave in any direction. Near the middle of the ledge are two layers, each about 20 inches in thickness, which are more regular; the rock, however, is found less broken as the excavation advances into the hill. Since this quarry is constantly worked for ballast, it has the advantage of selecting its best material for purposes of construction. However, stone more regular in structure and better adapted to building purposes is quite abundant in this locality. There is also a good flagging stone found here in a different stratum; but this is quarried only occasionally for temporary demands. The product of the quarry of the Baltimore and Ohio Railroad Company, near Barnesville, is used largely for ballast. It has been used to some extent for purposes of construction on the Baltimore and Ohio railroad. The stratum in which the quarry is located is about 30 feet in thickness, but has only been worked to a depth of 14 feet. The stratum contains few joints and has no divisional planes of stratification. Stone of such fair quality for all ordinary building purposes is so generally distributed throughout this part of the county that it is picked up wherever needed to supply the occasional local demands, and no extensive quarries are developed at any place for the production of building stone.

In Washington county strata of sandstone belonging to the upper series of Coal Measures are quarried for the production of building stone and grindstones in the heavy ledges along the Ohio River hills. The most important quarries are located near Marietta and Constitution. The arrangement of the different sandstone strata, with their alternate shales, coals, and fire-clays, is as follows:

Heavy sand-rock.....	30 feet.
Blue shale.....	9 feet.
Heavy sand-rock extensively quarried for grindstones.....	25 feet.
Sandy shale.....	20 feet.
Heavy sand-rock quarried in places.....	36 feet.
Shale, somewhat ferruginous.....	4 feet.
Coal, Hobson's seam.....	1 foot to 6 inches.
Fire-clay and shale.....	4 feet.
Interval to Ohio river.....	a 42 feet.

The quarries near Marietta and Constitution are all, except Mr. T. B. Townsend's, worked in the grindstone stratum, and produce, besides grindstones, material for all general building purposes. The building stone is used principally at Marietta and at various points along the Ohio river. In different portions of the stratum there are sufficient varieties of texture to furnish all kinds of grits used for wet grinding, and the grindstones are shipped to all manufacturing points in the United States. The rock splits readily in the direction of the stratification. The advantages offered for the transportation of the product by the proximity of the quarries to the Ohio river greatly aid their development.

The quarry of Mr. Townsend is located on the Muskingum river, and is devoted to the production of a material mainly for bridge-building purposes, and some for general purposes of construction. The section exposed in this quarry exhibits 65 feet of sand-rock, which becomes still heavier as the quarry progresses into the hill. It consists of layers from 4½ to 18 feet in thickness. In the lower portion of the quarry the material is rather finer in texture and superior in quality to that in the upper portion. The quarry was opened for the special purpose of obtaining stone for the ice harbor, now in process of construction at Marietta; but it also furnishes material for other structures.

## LIMESTONE.

**CINCINNATI GROUP.**—The southwestern corner of Ohio is covered by what is called the Cincinnati group of limestones, a geological formation equivalent to the Hudson River beds of New York. These rocks were very early quarried and used for construction purposes, although the special quarries that are at present in operation have been much more recently developed. Quarries once located on the outskirts of Cincinnati have suspended operations on account of the growth of the city. The material is mentioned in the early reports upon the geology of Ohio as having been used in 1838 for building, burning into lime, macadamizing roads, and even for ornamental purposes. (*a*)

Professor Orton gives the following as the order in which the beds which constitute the Cincinnati group in southwestern Ohio are arranged:

The Point Pleasant beds, 50 feet thick, constitute the lowest of the series. The Cincinnati beds proper overlie these, and are 425 feet thick. The Lebanon beds are the highest, and are 300 feet thick. Quarries are developed in each of these horizons. The rocks wherever they are quarried are very much alike, and are called in commerce blue limestones. As a rule they are filled with fossils, and occur in layers that are from half an inch to 12 inches in thickness, which are interstratified with beds of shale or clay. Professor Orton says that while this blue limestone has been used from the first settlement of the country, it has hitherto enjoyed the reputation of being serviceable rather than beautiful; but within the last few years it has been so treated by combination with other building stones as to produce very fine architectural effects, as can be seen in the recent buildings of the city and suburbs of Cincinnati. (*b*)

The quarries in the Cincinnati group of limestones are located near Cincinnati, more on account of the local demand for the most accessible stone than for the superior quality of the material at this point. There are limestones in the river bed which are upon the same level as the quarries which produce excellent stone at Covington, upon the opposite shore. These beds are overlaid by 250 feet of shales, which are called by Professor Orton the "Eden shales"; and these in turn are overlaid by the so-called "Hill Quarry" beds of limestones, from which most of the stone used in the county is derived.

Six quarries of importance are at present in operation at Cincinnati with exposures of from 40 to 75 feet, of which some 10 to 25 feet is distributed throughout the section in layers from 1 inch to 10 inches in thickness. Slabs 6 feet long and 6 feet wide can be extracted.

The lime which is burned from the stones of the Cincinnati group is dark and unfit for plastering, but for foundations, etc., it is of especial value, as it possesses some hydraulic capacity. Specifications for cellar walls, bridge abutments, etc., in this region always call for Cincinnati lime.

It is thus seen that the stone is interstratified with beds of shale, which forms from one-fourth to one-third of the whole section. In other parts of the series the proportion of stone falls to one-tenth of the thickness of the section, the main mass being composed of shale or clay. The stone seldom exists in such condition as to make a building stone that can be used in fronts, and it is mainly employed for rough construction, although some of the churches in Cincinnati have been built from it.

As the dip of the blue-limestone beds is mainly to the north, while the direction of the Ohio valley at Cincinnati is toward the south, by proceeding up the river layers of the formation are brought to the surface that are lower than any occurring in the river quarries of the city. The Point Pleasant quarries, in Clermont county, are consequently situated in a different and lower level, and Professor Orton states that this section furnishes the most desirable building stone of the blue-limestone series. It dresses more easily and possesses a better shade of color, combined with a general exemption from the weathered seams that disfigure the higher beds. The quarries are situated at the water's edge, and river transportation enables the stone to be brought to the city easily. In a church on the corner of Eighth and Elm streets, Cincinnati, the appearance of the stone can be seen to the best advantage. As the demand for the stone is local, the annual production fluctuates between wide limits, and the value of the product has sometimes fallen very low. There is quite a large number of small quarries in the neighborhood, each producing from \$200 to \$300 worth of stone annually.

The quarries in Butler county, from which are extracted the blue limestones of the Cincinnati group, are situated at and near Hamilton. The character of the stone and the method of its occurrence are the same as those of the other limestone obtained from this group. A quarry at Hamilton exhibits a section 40 feet thick, of which 18 feet are of stone distributed in layers of varying thickness throughout the whole section. The individual layers are from 1 inch to 12 inches in thickness, and the heaviest layers are found at the bottom.

The limestones of the Cincinnati group are all highly fossiliferous, and the number and variety of the forms found in them have given to them a geological celebrity. The quarrying operations are constantly bringing to light rare and interesting species, but the specimens which were collected and sent to the National Museum as typical contain a predominating number of fossils of the species *Chaetetes*, with the shells of brachiopods cemented together by limestone. When polished the stones appear very beautiful on account of the diversity and delicacy of these fossil forms, but owing to the presence of clay in the cementing material the polish is not uniform.

*a* Professor Locke in *Second Annual Report on Geological Survey of Ohio*, by W. W. Mather, 1838.

*b* *Report of the Geological Survey of Ohio*, Vol. I, Part i, p. 378.

over the whole surface. This does not detract especially from the value of the stone for ornamental purposes, since the fossil forms which give the stone its beauty by receiving the highest polish are thereby brought into prominence.

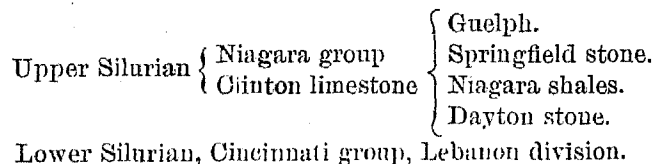
The fragments of fossils of which the stone so largely consists were apparently first washed together along with the clayey limestone and mud which forms the cement, and which fills the interiors of the fossil forms. This was apparently solidified into a vesicular rock, and the cavities were subsequently filled with clear crystalline calcite. The process of such formation is frequently seen in the Ohio limestones, some of which are porous, and are filled with cavities which are but partially filled with new crystalline product. Analyses were made of these limestones by Dr. Wormley for the *Report on the Geological Survey of Ohio*. (a)

The Point Pleasant rock, which is considered to be the best for building purposes, was by him shown to have the following composition:

	Per cent.
Siliceous matter.....	12.00
Alumina and iron oxide.....	7.00
Calcium carbonate.....	79.30
Magnesium.....	0.91
Total.....	<u>99.21</u>

NIAGARA GROUP.—The rocks of the Niagara period occupy that portion of Preble county in which quarries are extensively developed. The Niagara limestones in Ohio are very often called the Cliff limestones, because they stand in bluffs along the river valleys, and they are more esteemed as building stones than the rocks of the underlying Cincinnati group.

The following sketch by Professor Orton shows the arrangement of the rocks in this county: (b)



The approximate thicknesses of the divisions are about as follows:

	Feet.
Niagara group.....	75
Clinton limestone.....	15
Cincinnati group.....	225

Of these stones the blue limestone is quarried in the southern part of the county, and was formerly the main dependence in that region as a source of lime, but the Cliff limestone was brought subsequently into universal use as a substitute.

The Clinton limestone has been largely in demand for chimney-backs, and has been found especially desirable for all those constructions which are exposed to fire or heat. It is an unevenly-bedded stone, often sandy in texture, but no quarries are so extensively developed in it as to merit consideration.

The stone which is quarried near Eaton is the geological equivalent of the building stone of Springfield and Yellow Springs. One of the largest and oldest of the quarries is 3 miles northeast of Eaton; another,  $5\frac{1}{2}$  miles northeast of Eaton, is smaller. A section of the first quarry shows 6 feet of so-called cutting stone at the bottom overlaid by 4 feet of a good building stone with  $3\frac{1}{2}$  feet of drift material upon the top. A number of grades of material are quarried, and stone suitable for flaggings and copings, as well as for fine and rough constructions, is obtained.

It is stated that a stone 10 by 12 feet in superficial dimensions has been taken out, and that very much larger stones can be obtained. It is principally used for rough building purposes and is sent to Eaton, Ohio, and to Richmond, Indiana, by team and by rail.

These quarries yield an unusually fine quality of flagging stone, the material lying in very even courses of suitable thickness. An analysis of the limestone was made for the Ohio survey by Professor Wormley, (c) and the composition of the stone is shown to be as follows:

Calcium carbonate.....	49.75
Magnesium.....	35.87
Alumina and iron oxide.....	4.40
Siliceous matter.....	9.40
Total.....	<u>99.42</u>

a *Geology of Ohio*, Vol. I, Part i, p. 374.

b *Geological Survey of Ohio*, Vol. III, Part i, p. 405.

c *Report of the Geological Survey of Ohio*, Vol. III, Part i, p. 409.

The largest quarries in Preble county are located at New Paris. The building-stone courses are here accessible, but the production of burned lime is the chief industry, yielding twelve-nineteenths of the gross earnings; the lime is distributed mainly to the westward by the railroads leading out of Richmond, Indiana. The quarries produce also flaggings, copings, bridge and building stones—in fact, the material for any construction can be here obtained.

Immense blocks are said to have been quarried at this place. The chief market for the stone quarried at New Paris is in eastern Indiana. The specimens sent to the National Museum from Preble county are all of a drab color, compact, and rather earthy in appearance, incapable of taking a high polish, and possessing a characteristic appearance due to the presence of porphyritic crystals of a clear, glassy nature, and which become very prominent upon the smooth or polished surfaces. These glassy crystals are of calcite, and the forms of the fossils which are sometimes seen are filled with the same glassy material. The earthy ground mass, which constitutes the bulk of the rock, will not dissolve in dilute acid, and is of a dolomitic character, as is shown by the analyses that have been cited. The stones consist of irregular, minute grains, which are closely fitted together with rhombohedral crystals of dolomite developed among them. All of the sections when magnified show very numerous but exceedingly small particles of pyrites. This is what probably produced the 4 or 6 inches of sap or discolored rock adjoining the natural clefts.

The limestones quarried at Piqua, Miami county, are from the lowest horizon of the Niagara formation, (a) and are therefore the exact equivalents of the Dayton stone. They are immediately underlaid by the Clinton limestones, and the glacial action has plowed away the stones of the Springfield and Covington type which once overlaid them. The material here extracted is of good quality. The stone lands sometimes bring \$2,000 per acre near Dayton, and their value is indicated by the circumstance that, although the stone is not more than 16 feet in thickness, it is frequently extracted in places where 20 feet of dirt and drift must be removed from above it. The stone belonging to this horizon is usually very strong, specimens having been found to resist a crushing force of 30 tons on a 2-inch cube. The quarries are situated at and directly south of Piqua, upon the west side of the river, with the exception of one quarry  $2\frac{1}{2}$  miles south of the town. The material is sent by rail, canal, and team to the neighboring towns and cities of Ohio and Indiana, where it is used mostly for rough building purposes. No prominent structures have as yet been constructed from it. The thickness of the strata varies, and it is therefore possible to obtain slabs suitable for pavements. Indeed, it is claimed that slabs 20 feet square from some quarries are accessible. The town of Piqua is mostly paved with this stone, utilizing for this purpose the poorer and inferior layers. The walks would be greatly improved by the use of the better layers.

In the quarries immediately at Piqua about  $2\frac{1}{2}$  feet of the lowest layers are heavy and thick, and are used for bridge stones. Then follow about 7 feet of building stone, overlaid in one quarry by 1 foot of well stone and 2 feet of drift, and in the others there are 7 or 8 feet of drift to be removed. Quarries below the town are overlaid by 22 feet of drift, the lower portion of which is composed of fragments of broken limestone, of all sizes and shapes, piled together with an intermixture of gravel. This stone, like the Dayton stone, is mainly composed of calcium carbonate, which, it is said, usually constitutes over 90 per cent. of the whole. That it varies, however, between quite wide limits is shown by the circumstance that of the two specimens sent on one is quite dolomitic, and will dissolve but little in dilute hydrochloric acid. It contains streaks and clear crystalline spots, which are of calcium carbonate, and under the microscope in minute structure it is found to contain more or less of sharply-defined crystals, which are probably of dolomite. The stone in some of its layers contains more or less of pyrites, and is mainly of the variety which is called blue limestone. Some of it will receive a tolerably fair polish, and when thus treated it has a prettily-mottled structure, or a gray- and white-banded structure, according as the blocks are polished upon a plane parallel or perpendicular to the stratification.

The Dayton limestone is an evenly-bedded, massive, gray carbonate of lime, which is sparingly charged with fossils, and which is quarried from the very lowermost courses of the Niagara formation. It is found in firm, heavy courses that are at times 10 feet in thickness, though often very much less. So-called cutting stone is obtained from these beds. This term "cutting stone" is generally employed to designate stone which comes out in large blocks suitable for steps, platforms, etc. Cutting stone is sharply distinguished from building stones in all the quarries of western Ohio, and brings several times the price per cubic foot. The thinner and inferior strata serve a great diversity of uses.

Although stone of excellent quality occurs in various portions of Montgomery and Greene counties, the market has been thus far largely supplied by the quarries situated in the neighborhood of Dayton. Five quarries have there been opened in a belt which lies a mile and a half east of the town, whose sections exhibit 5 feet of the so-called cutting stone, overlaid by from 10 to 18 feet of drift. They produce all kinds of building stone (graded in from three to six grades), which is mainly sent to Dayton and to Cincinnati. The court-house and some of the churches in Dayton were constructed of this stone.

Another quarry in this same horizon, situated  $7\frac{1}{2}$  miles north of Dayton, has only 5 feet of drift to be removed; but, on the other hand, the thickness of the stratum of cutting stone is least in this quarry. The court-house at Sidney, Ohio, is built of this stone.

At a quarry operated 6 miles east of Dayton the deposit consists of 4 feet of cutting stone, overlaid by 6 feet of a yellow-colored stone, the whole capped by 9 feet of drift. Two miles farther to the east lies a quarry which contains 4 feet of cutting stone overlaid by 3 feet of drift. The last two quarries are in Greene county.

Quarries have been opened in the same stratum of stone in the neighborhood of Xenia, and these have been widely known and extensively worked. This is in fact one of the three localities to which the contracts for the foundations of large works in Cincinnati were formerly confined, the specifications calling for Xenia, Centerville, or Dayton stone. This is the easternmost exposure of the last-named stone. The Dayton limestone is a peculiar and exceptional member of the great Niagara series in southwestern Ohio. It lies in lenticular masses of comparatively small extent, perhaps not more than two or three square miles occurring in any one area. Throughout Montgomery and Greene counties the shale, which forms the next succeeding layer of the Niagara formation, has in almost all cases been removed by erosion, and thus it happens that the stone is immediately covered with the deposits of bowlders, clay, and dirt, as described. The glaciers which have produced this result have polished and striated the rocks in many cases.

The composition of the Dayton limestone is shown from the following analysis, made by Dr. Locke in 1838: (a)

	Per cent.
Calcium carbonate.....	92.40
Magnesium carbonate.....	1.10
Iron protoxide.....	0.53
Insoluble material.....	1.70
Soluble silica.....	0.90
Water.....	1.08
Total.....	<u>97.71</u>

The stone from the McDonald quarry, near Xenia, has been analyzed by Professor Wormley, (b) with the following result:

	Per cent.
Calcium carbonate.....	84.50
Magnesium carbonate.....	11.16
Alumina and iron oxide.....	2.00
Siliceous matter.....	2.20
Total.....	<u>99.86</u>

When examined under the microscope these stones, as illustrated by the samples sent, are found to be composed largely of fossil fragments, which are so broken and destroyed as to be unrecognizable to the unaided eye. These fragments are united by an extremely fine ground mass, in which here and there a sharply-defined rhombohedral form is porphyritically developed. These porphyritic crystals are quite prominent in the stone from the Huffman Stone Company's quarry, near Dayton. A section of this stone was treated with dilute acid, when everything dissolved with the greatest facility, with the exception of these porphyritic crystals, which may consequently be supposed to be rhombohedrons of dolomite which have developed themselves in the mass of calcite.

Although stones of such excellent quality are obtained from the Dayton beds, it is necessary to mention that stones occur in which pyrites exist in large crystals at least half an inch square. Pyrites is recognizable in the thin section of all specimens sent to us, though this ingredient is not so disastrous in a stone of this nature as it is in other more porous stones, in which the pyrites would not merely be reached much quicker by the decomposing agencies, but in which the products of decomposition would more quickly find their way through the cracks and crevices of the stone. The material has attained a high reputation. It was used at one time extensively at Chicago, and the lowest story of the Chamber of Commerce edifice is built of it. Cincinnati has used it largely, but for the last 15 or 20 years it has not been shipped so extensively to these points.

Beds of the Dayton limestone are developed in Clinton county. They have been quarried at Wilmington and Centerville, but the old quarries which have been reported as in active operation during the census year are situated  $1\frac{1}{4}$  miles southwestward from Lumberton. The quarry consists of 5 feet of stone, which is mostly used for rough building purposes, and is overlaid by 2 feet of drift. The material is hard, very compact, and capable even of assuming a quite high polish. It is also very noticeable that the rock, which to the unaided eye appears so compact and non-fossiliferous, really contains a very great number of fossil fragments. It also contains some pyrites, distributed through the mass in the form of very sharply defined cubical crystals, which in the specimens sent are entirely invisible to the unaided eye, and which cannot be called deleterious. There are yellowish spots and streaks in some of the layers, but this appears to result from the inclusion of clayey material rather than from the oxidation of the iron sulphide. The stone from this quarry finds its market principally in Clinton and Fayette counties.

The rocks in Clarke county (c) are like those found in Montgomery and Greene counties, but the important quarrying operations are all carried on in the upper beds of the Niagara formation, which are typically developed.

a Report of Progress upon the Geological Survey of Ohio, 1869, p. 152.

b Geological Survey of Ohio, Vol. II, Part i, p. 669.

c Geological Survey of Ohio, Vol. I, Part i, p. 450: "Geology of Clarke County", by Edward Orton.



at and about Springfield. These beds are of particular value, as they possess a greater thickness than any one of the underlying formations in the county, and cover a much wider area. In the same quarries building stones of excellent quality are combined with material that is converted into peculiarly excellent lime. The accompanying section of the rocks at Springfield indicates the relationship of the beds.

The underlying shale occupies the position of the limestone which is quarried so extensively at Dayton and at Piqua. The overlying beds of building stone have given the name to the so-called Springfield division of the Niagara, and the less compact layers of the overlying so-called Guelph formation are broken up and burned.

The Springfield building stone is a carbonate of lime and magnesia, containing only small percentages of silica and alumina. Its usual color is a light drab, although blue and yellow courses occur. The light-colored stone sometimes is defaced by faint reddish streaks which are caused by the presence of iron oxide, and which render the stone unfit for some of the finer uses. The thickness of this deposit of building stone is not more than 20 feet, and is usually less. The lowest courses are blue in color, and although massive in appearance, they sometimes prove treacherous as building stones, for they are liable to lose their dressed surfaces, while their seams widen and they undergo a slow disintegration. The walls of the jail in Springfield furnish an illustration of these characteristics. The drab courses are almost all of durable building stone, and furnish an invaluable supply of building material for Springfield and the adjacent country.

The difference between the blue and the yellow courses in most of the limestones of Ohio appears to depend upon whether the iron exists as pyrites or as oxide of iron. The pyrites existing in a fine state of subdivision appears black even under the microscope, and the blue color of the stones apparently disappears with the oxidation of the pyrites. This furnishes an illustration of the circumstance that stones are often improved by decompositions which take place inside the beds, for if their value is not thereby destroyed there is much less danger of a disintegration by a decomposition of the quarried stones.

From quarries within  $1\frac{1}{2}$  miles west of Springfield the material for the culverts in the state road were obtained, and the material for the bridge at Marysville and for the Masonic hall at Urbana. These quarries are known as the old state quarries, because the material was used in many constructions on the state road. The quarries are large, but the stone from them is used chiefly in building cellar walls, foundations, and other rough work of a similar nature.

Two miles west of Springfield are situated four quarries which furnish similar stone, that is used in Springfield, Dayton, Urbana, London, and Marysville. In all of them the cap-rocks are burned into lime, and the larger portion of the profits results from its sale.

In all cases it is the overlying Guelph beds which are burned, as the courses of building stones contain a considerable percentage of silica and alumina, and cannot be converted into good lime, although some of this material makes a fair cement. The lime product of these quarries finds its way in small quantities as far as New Orleans. It is mild, cool, and strong, and also very white. There is no trouble in laying seven bricks with one spreading of mortar, and skillful workmen can lay twelve bricks with one spreading. The superior quality of this lime is worthy of note, since it is ordinarily considered that the value of lime is diminished by the presence of magnesia.

The composition of the Springfield limestones is shown by the following analyses of the middle and upper beds in Mr. Frey's quarries near Springfield. These analyses were made by Professor Wormley for the *Report on the Geological Survey of Ohio*: (a)

	Middle bed.	Upper bed.
Calcium carbonate.....	54.70	54.70
Magnesium carbonate.....	44.93	42.37
Alumina and iron sesquioxide.....	0.20	1.00
Siliceous matter.....	0.10	1.50
Total.....	99.93	99.57

It is thus seen that the rocks are very nearly typical dolomites. They vary somewhat in composition, but not so as to at all influence their value as building stones. They possess an open and porous structure, and are incapable of assuming a polish or being used for ornamental purposes. In their microscopic structure they are seen to be of the crystalline granular type, the fossiliferous character being obliterated from the microscopic structure, although fossils are not rare in the rock.

The Yellow Springs quarries produce a magnesian limestone which is very easily worked, and the larger part of which is durable. These quarries are upon the same horizon as the Springfield quarries, and produce stone of the same nature. The courses vary in thickness from 4 to 14 inches, and some of them answer very well for cutting stone. The same qualified commendation can be given to them for flagging, but the quarries have not been extensively developed with the end in view of producing this material. For general masonry the stone has proved very serviceable, and for economy is not surpassed by any stone in the state. There are two colors, which are obtained from different courses, and which are denominated as blue and drab; the blue courses weather to drab in exposed

places, but it is not certain that all of the drab beds have been made by oxidation of blue layers. The blue beds sometimes prove treacherous, and even the firm and massive appearance of the stone furnishes no safe guide in judging of its power to withstand the atmosphere. By far the larger portion, however, is excellent in this respect, and the drab courses are almost without exception satisfactory.

Three-quarters of the gross earnings of these quarries are, on an average, obtained from the sale of lime, sent to market under the name of the Springfield lime, which is the standard for southwestern Ohio.

A section of the quarry shows at the bottom some layers of building and cutting stone, above which is a 10-foot bed of solid limestone containing pentamerous fossils, and above are 18 feet of the "shelly" limestone, which is burned. The principal quarry at this place produces stone for bridges, steps, and sills, which are principally used in the vicinity of Yellow Springs. The composition of the stone from this quarry is indicated by the following analysis by Professor Wormley: (a)

	Per cent.
Calcium carbonate.....	51.10
Magnesium carbonate.....	41.12
Sand and silica .....	5.40
Alumina, with a trace of iron oxide.....	1.40
Total.....	<u>99.02</u>

The quarries in Miami county resemble those at Springfield, and are located in the same geological stratum. They are rendered valuable by the circumstance that for 50 miles in some directions there is no other developed quarry. To the northeast, north, and northwest the region is heavily buried under beds of drift, and consequently building stones are inaccessible. The material from the Covington quarries is distributed, therefore, very widely. The stripping is light, the drainage easy, the quantity and quality of the stone are both excellent, and great variety exists in the thickness of the various strata.

The Covington stone is chiefly used for building and bridge construction, and it is mostly consumed in Covington, Ohio, and Winchester and Marion, Indiana. Some bridges on the Pan-Handle railroad have been constructed from this material. At the town of Covington there are six quarries in active operation, as indicated by the table. Some of these must soon be given up, for they lie within the city limits, and houses are being now constructed in their immediate neighborhood.

The material resembles that which is quarried at Springfield in being porous and easily cut. Of the specimens sent to the museum one was blue and one yellow, and upon examination it was found that they differed not merely in the circumstance already mentioned, in that the blue layers contain unoxidized pyrites and the other hydrous iron oxide, but the blue specimen was a dolomite which would not effervesce in acids, while the yellow specimen was much more calcareous. In microscopic properties this stone presents no peculiarities. It belongs to what we have designated as the porphyritic type; that is, it contains rhombohedral crystals of dolomite developed in a mass of formless grains of calcite.

In Shelby county the upper portion of the Niagara formation is developed, and several quarries have been opened, the products of which are almost entirely burned into lime. Building stones can be there obtained at any time and in any quantity desired.

Hancock county is occupied by rocks of the Niagara and Helderberg periods, and although the Niagara rocks which from here extend in a narrow strip northward to lake Erie appear to be separated from that great area of Niagara rocks in which the Springfield and Dayton quarries are situated; they probably extend beneath the Helderberg rocks that intervene and form a portion of the same deposit. The rocks quarried at Findlay possess characters almost identical with those of the Springfield stones. They possess a rather porous and open structure, are drab in color, and occur in courses from 3 to 12 inches in thickness. The stone is strong and durable, and none of it has as yet shown any bad effects from exposure to moisture or frost. It is rather hard to dress, and stone-workers call it "plucky". The horizontal surfaces are generally roughened by small angular prominences which fit into corresponding depressions in the superimposed layer, forming the structure which is known as "suture" jointings. The dip here is very slight, and the top course in all of the Findlay quarries is evenly bedded and about 1 foot thick. The "seams" (open joints) are from 25 to 100 feet apart, and those joints usually run at right angles to these seams at greater or less intervals. For this reason, if the quarry is stripped over a sufficient space, the rock can be obtained without blasting. The material from these quarries is used for foundations of buildings and for bridge abutments in the county, and last year some was shipped to Seneca and Allen counties.

In composition the stone from the Findlay quarries is dolomitic and possesses the characters of the upper Niagara beds. In microscopic structure it is beautifully crystalline, the whole mass of the rock being made up of an aggregate of more or less well-defined rhombohedral crystals.

It appears that blocks much larger than can possibly be required are obtainable here, and that the material, although at present used only for rough construction, could be safely applied as a building stone. Although the present quarries have been opened quite recently along the same streams upon which these are situated, and within a short distance of them, quarries have been in operation for more than twenty years.

**HELDERBERG.**—The Helderberg formation is exposed in a narrow strip (*a*) upon the boundaries of Highland and Ross counties, and indeed more stone is taken from the quarries at Greenfield than from any others in the Helderberg formation of Ohio. The stone is regular in its bedding, and, therefore, curbing and crossings of excellent quality are easily extracted. In the Cincinnati market it is largely employed for these purposes. Slabs 3 or 4 inches thick, with a superficial area of 4 feet, can be obtained with surfaces as smooth and regular as if sawed. These stones can be used for door-steps and like purposes without any dressing. The courses are never heavy, seldom exceeding 14 inches, and usually ranging between 4 and 8 inches in thickness. The stone is exceedingly strong, 2-inch cubes having been found to stand a pressure of over 50,000 pounds. The quarries produce no waste material, and their spalls are saved to be burned into lime of fair quality. Perpetual kilns are set upon the edge of the Greenfield quarries, the floors of which are kept clean and free from accumulations of refuse of any kind, and the lime produced is similar to that obtained from the Niagara formations, but it possesses in some degree hydraulic properties which make it especially adaptable for outside work.

The stone produced is drab in color when first raised, but upon exposure it generally acquires a yellowish-brown shade. It is ordinarily used only for the rougher purposes of construction and for flaggings and curbing, but, by proper selection and skillful dressing, stone can be obtained from the quarries that produce a good architectural effect. Without such an exercise of taste and judgment, the stone does not appear well, owing to its monotonous gray color, which contrasts unpleasantly with the white lines of mortar. On the other hand, its regular bedding renders it peculiarly suitable for ordinary purposes, as it can be laid upon its even bed surfaces easily, and therefore can be worked with facility and economy. The stone finds its principal market in Cincinnati.

It will be noticed that of the large quarries which supply the Cincinnati market but one is in Highland county. The other is situated in the town of Greenfield, in Ross county. In the Highland County quarry one-twentieth of the profit results from the sale of lime, but in the Ross County quarry more than one-half is burned.

In the Ross County quarry the section shows 42 feet of stone disposed in layers, all of which are available. The quarry is capped by 10 feet of drift material, which constitutes all of the stripping. The Highland County quarry shows 35 feet of stone of a like character overlaid by 6 feet of drift.

The stone in the main is non-fossiliferous, but upon the surfaces of a few layers there are found the forms of the *Leperditia alta*, which is a characteristic fossil of the Helderberg formation. A layer of concretions from 1 inch to 3 inches in diameter is found in the upper part of the section, and short cylindrical columns which fall out, leaving cylindrical cavities in the stone 3 or 4 inches in diameter, occur in considerable numbers, and which are supposed to be due to the effects of pressure.

Nodules of zinc-blende are not uncommon in the Greenfield stone, and the fossil corals are sometimes composed of silica, which also is distributed through some of the stone in bands that separate the layers.

In composition the stone is nearly a typical dolomite, as is indicated by the following analysis: (*b*)

	Per cent.
Calcium carbonate.....	53.67
Magnesium carbonate.....	42.42
Alumina and iron.....	
Sesquioxide.....	1.30
Calcium and magnesium silicates.....	1.44
Silica.....	1.00
Total.....	99.83

When examined under the microscope the whole stone shows the characteristic crystalline granular structure of the Helderberg formation. There are streaks of iron oxide and carbonaceous matter which proceed in regular wavy lines through the sections, and these bituminous substances are what give to the stone the strong fetid odor which is produced by striking or cutting it. The quality of the lime produced is another evidence that magnesian limestones may be converted into lime of excellent quality.

Quarry operations have been carried on at Greenfield since the first settlement of the country to satisfy the local demand, but in recent times the business has been greatly enlarged for the more distant markets along the line of the railroads, and especially for the Cincinnati demand. The supply of stone is practically inexhaustible.

In the southern and western part of Champaign county the Helderberg or Water-lime rocks have been quarried in numerous places; formerly a quarry at Salem supplied most of the local demand, and the building and flagging stones used in Urbana were obtained there until the sandstone of Berea superseded them. The stone obtained in the neighborhood of Urbana is of indifferent quality for building purposes, but here it is found in a drift-covered region in an area which for 25 or 30 miles in each direction is devoid of stone. Only about 14 feet of the upper strata have been much quarried. The floor has been sunk to a greater depth, and the stone from the lower courses is proving itself to be a valuable building stone for rougher work. There is no so-called cutting stone in the quarry,

*a* Geological Survey of Ohio, Report of Progress in 1870, p. 255: "Geology of Highland County," by Professor Edward Orton.

*b* Report of Progress of Geological Survey of Ohio, 1870, p. 287.

and the accompanying section will give an idea of the method in which the strata of the Helderberg are arranged at this point. It will be noticed that there is much greater diversity as regards stratification than is shown in the Greenfield quarries.

The specimen sent to the National Museum is a light drab stone, somewhat streaked with red. Its material is of the same character as that of the other Helderberg stones—that is, a dolomite with a fine, crystalline, microscopic structure, and which emits a bituminous odor when struck with a hammer, although the odor is not so strong as in the case of some other Helderberg rocks.

Allen county is almost entirely covered by limestones of the Water-lime or Helderberg formation, (a) and all of the quarries that have been considered worthy of note extract stone from these beds that is used for the more ordinary building purposes and for foundations and underpinnings. The upper beds of the Niagara formation occur in the southeastern corner of the county, and a few quarries were once opened in those rocks, but the building material that was extracted was inferior, and the production of quicklime from them was not profitable.

Although the building stone obtained from the Helderberg is, as a rule, not of excellent quality, still, as it is the only accessible material, it is of much value.

The stone quarried directly in Lima is an inferior building stone, and is seldom used for foundations above ground, but is in demand for the underground portions of foundations. The quarry is worked more to obtain stone for macadamizing than for any other purpose. It occurs in thin layers, and a block 6 inches thick is seldom obtained. This thinly-bedded character renders it applicable as a flagging stone; the bedding, however, is uneven.

The material obtained from this quarry is a dark gray dolomite, which is quite porous in its character; it dissolves in hot acid with very little residue, and the solution is found to contain only traces of iron oxide, which the microscope proves to exist in the state of pyrites. The polishing of a face upon this stone renders its fossiliferous character very prominent, which is not common in the rocks of this formation. The stone is very bituminous and gives forth a foul odor when struck with the hammer.

A quarry 4 miles north of Lima is said to produce some material of a much better quality. It is situated near the Dayton and Michigan railroad, but a side track could not be constructed to it without considerable expense on account of the heavy grading that would be necessary. Some of the courses are over 1 foot thick, and some from 4 to 6 inches thick have been used for sidewalk paving in front of the Lima machine works, where it gives indication of both strength and durability. The following is a section of the strata in the quarry:

	Feet.
Soil .....	3
Building stone for ordinary foundations .....	3
Dark gray paving stone .....	1½
Blue shaly material .....	—
Blue-stone .....	—

There is no natural drainage below the paving stone, and for this reason the underlying blue-stone has not been extensively quarried. According to the testimony of all builders and contractors the stone in the bottom of this quarry is the best building material found within a radius of at least 30 miles. The shaly rock which overlies the blue-stone forms good material for the macadamizing of roads. The material above the paving stone, which is used for foundations, occurs in thin beds which are never more than 3 inches in thickness.

The specimen which was sent from this quarry was taken from the lower or "blue-stone" layers; it has a dark gray color, finely banded with yet darker lines, and much more compact than most of the stones sent from the quarries in the Helderberg. Indeed, no pores or cavities were found in it, and its texture was such that it admitted of a fair polish, as indeed do most of the Helderberg limestones. The stone from this quarry is a dolomite, but on being dissolved in hot acid quite a large residue of argillaceous character is left undissolved, and it contains bituminous substances which impart to it the character of a fetid limestone. It contains little or no iron.

A quarry is situated 5½ miles northeast of Lima, and the following section indicates its character and the uses to which the stone is applied:

Stripping .....	feet... 5
Road stone .....	do... 3
Gray building stones .....	do... 3
Two courses of blue-stone .....	inches... 6
Blue clay .....	do... ½
Gray building stone .....	do... —

As in the case of the preceding quarry, the thickness of the stratum of the gray building stone is as yet undetermined. It occurs in courses from 3 to 6 inches thick. The upper 3 feet of stone, which is used for the purpose of macadamizing, is extracted with neither profit nor loss. The material is a more or less porous dolomite of a gray color, mottled and streaked with black, which is due to the arrangement of the bituminous substances contained in the stone. Of the two specimens sent to the National Museum, one was polished upon a surface parallel with the stratification, and this treatment developed a beautiful structure, due to the presence of

a fossil bryozoan, which filled the layer that was cut. Thus the presence of a fossil in abundance was demonstrated although the rough stone gave no indication of a fossiliferous character. This stone and the one previously described from Lima are the only stones of a fossiliferous character which were sent to the Museum, and which were obtained from the Helderberg formation.

These stones are thus most markedly contrasted with those from the Niagara, which are almost all fossiliferous, as is indicated by microscopic examination, which very often renders the forms evident when they are invisible to the naked eye.

In the eastern part of the township of Bluffton the quarries are better adapted to supplying flagging than building stone, since the thickness of the strata usually varies from 1 inch to 3 inches. When properly laid down these slabs make a very durable paving material for sidewalks, cellar bottoms, etc. They are very hard, but break quite easily into any required shape. The stone is dark-colored and of the same character as those previously described. Its color is imparted to it by bituminous substances, and the dark streaks with which it is filled are very irregular, so that a pattern not at all unattractive to the eye is developed upon the smooth or polished surfaces of the blocks, and when dressed in the usual way and laid with white mortar they make a beautiful wall for smaller buildings. Such large blocks have been moved as to insure the possibility of obtaining blocks as large as might be desired.

Although the quarries described have been recently opened, the stone has been quarried in the immediate neighborhood for fifteen years.

Scott's Crossing is situated 4 miles east of Delphos, on the Pittsburgh, Fort Wayne, and Chicago railroad. A quarry at this place produced a drab-colored limestone, which occurs in courses from 3 to 11 inches thick, and which serves very well for foundations. Samples which have been in walls for over fifty years show no signs of decay. The quarry is situated in the bed of the Auglaize river, and is not worked early in the spring nor late in the fall, when the water is high. A slight dam is built about the quarry, which is washed out every winter, and in addition heavy rains in the summer frequently destroy the works. No more permanent dam is built, since the site of the quarry is often changed, and no excavation has been made in the vicinity to exceed 6 feet in depth. The material is mostly used in the vicinity for bridge abutments and at Delphos for foundations for buildings. It has been sent, to a limited extent, into Mercer county, over the Toledo, Delphos, and Birmingham railroad, to localities where the Piqua stone is not so readily sent. Ten inches of coarse sand, gravel, and other river deposits cover the stone, and about 18 inches of the cap-rock is used upon the public highways. This is one of the best building stones quarried in Allen county for the purposes to which it is applied.

Van Wert county is covered in its northwestern part by the Niagara beds. The Helderberg limestone underlies the rest of the county, but only a few exposures of the rock of either kind are known, as the whole region is mostly covered by drift. (a) The county is entirely agricultural, and the stones where quarried furnish materials that are used only for foundations in that neighborhood or burned for lime. The lime-kilns at Straughn have caused the most extensive quarrying operations, and the Helderberg stones there extracted are said to burn easily and cheaply to a beautiful white lime. The Van Wert quarry, which is the only one reported as producing any considerable amount of building material, also produces quicklime; and during the last census year the value of the lime produced was about equal to that of the building stone. The Van Wert stone is a light gray dolomite, which is found in courses from 3 to 7 inches thick. The material thus far has given evidence of being a good building stone. Openings have been made in the limestone at several other points in the county; for example, on the Little Auglaize, in the northeastern part of the county, a stone very much like the Bluffton limestone has been quarried to a small extent for the Delphos market. In the northwestern part of the county some building stone is said to have been obtained in much thicker courses than in any other part.

A very light gray limestone has been quarried at Charloe, on the Auglaize river, in Paulding county, which belongs to the Corniferous formation. This Paulding limestone is a soft stone which occurs in courses about 3 feet thick. It has been sawed, and was used in the foundation of the court-house and also in that of the Russel House at Defiance, where it has suffered from the action of moisture and frost. As other specimens of the same stone do not show this disintegration, its defective character is very likely due to the circumstance that it was quarried too late in the season. A blue limestone is also quarried about 5 miles farther down the river from Charloe, which occurs in courses from 6 to 18 inches thick, and has been used for the construction of locks on the Miami and Erie canal. It is not durable when exposed to atmospheric action, and the quarries have been abandoned. The demand for the material has been destroyed by the introduction of the White House stone from the north and the Piqua stone from the south.

Tiffin is situated exactly upon the boundary between the Niagara and the Helderberg rocks, in Seneca county, and its quarries, although producing only Helderberg rocks, show at some times at their bases exposures of the underlying Niagara limestones. These quarries are located on the eastern side of the ridge known as the Cincinnati axis, and the characteristics of the rocks are much the same as those in the quarries on the western side of the anticlinal in the Helderberg formation; but the stones at Tiffin are more massive, and are therefore more suitable

for heavy construction. The courses are often 26 inches in thickness, and the stones produced are used largely for foundations and bridge work. The product of quicklime from these quarries is also large.

The stone is light drab in color; it is bituminous, and gives forth a strong odor when hammered, but this characteristic is not so marked as in the dark-colored varieties. The principal market for all three of the quarries situated in Tiffin is furnished by the immediate neighborhood. Beside the quarries in the table there are several smaller ones which are worked in the vicinity of the town, and which produce the same kind of material in less amount.

A short distance west of Fremont several quarries have been opened in the strata of the Water-lime or Helderberg formation.

The only quarry at this point of sufficient importance on account of its production of building stone is situated one mile to the west of Fremont, and in this the value of the lime which was produced from the quarry during the census year was ten times that of the building stone. The strata suitable for building purposes are from 1 foot to 10 feet in thickness, and the material which does not make an excellent quicklime is comparatively small. As a building stone the material is superior to much of that used in counties to the southwest, although not equal to the Sandusky and Marblehead limestones. It is of a light drab color, full of small cavities, and works very easily, and some of it is soft and pure enough to be sawed. The stripping is sold for macadamizing. It presents the usual microscopic characteristics of the Helderberg rocks, and it dissolves in hot acid, leaving a very slight residue. The qualitative analysis indicates that it is composed of remarkably pure dolomite.

**CORNIFEROUS.**—Quite a variety of stone is found in the neighborhood of Columbus, for although Franklin county is flat it has a number of geological formations within its limits. To the east lie the Waverly sandstones and the Huron shale, but the limestones of the Corniferous, which lie to the west of Columbus, are by far the most important from an economic standpoint. Thick and heavy layers of stone exist among the strata. From the different layers material suitable for the most diverse uses can be obtained, good quicklime can be made, and being in part a very pure carbonate of lime the stone is desirable as a flux for smelting iron ores. Of late it has been very extensively applied to the latter purpose, especially in the Hocking Valley region. The quarries are all situated a few miles to the west of Columbus, and have been operated for a long time. Some which have been the most important, for instance the state quarries, from which the material for the state-house and for the walls of the state-prison was extracted, are no longer worked, but all of the quarries mentioned in these tables are immediately about the old quarries and extract the same material. While the state-house was in process of construction, and stone of the best quality was in demand, the Corniferous limestone was worked to a greater depth than it is at present, for the finest quality of stone is found in the lower layers. At present the production of building stone is subordinate to the production of lime and flux.

The Columbus limestone is dense, compact, and strong. There are 12 feet of the upper courses in the present quarries that average 93 per cent. of carbonate of lime, and frequently the percentage rises to 95 or 96, while, on the other hand, there are localities where the Corniferous limestone becomes nearly a typical dolomite, as at Bellefontaine. The stone is fossiliferous, but the fossils are very firmly cemented and do not appear to weather out; in some cases, indeed, the fossil appears to be firmer than its surrounding stone. In microscopic structure the stone bears the appearance of a fragmental stone, being composed almost entirely of fragments of fossils. In the finer ground mass very perfect little rhombohedrons of dolomite are developed, which in number are apparently disproportionate to the amount of magnesia contained in the stone. Many of the fossils have apparently retained their primitive condition, but others have been dissolved away and the forms filled with crystalline calcite; and this will perhaps explain the different behavior of the fossils in weathering. The stone is somewhat bituminous in character, as evinced by the odor emitted when struck. Its gray color is pleasing to the eye; it works easily, and will even assume a good polish.

Dynamite is used as an explosive to a large extent, any desired number of charges being exploded simultaneously by means of electricity.

Although the common stone for foundations and underpinnings used in Columbus is obtained from the quarries, still, during the census year, no great amount of building stone was extracted, and no important structures were built from the material. The quarries can at any time be operated much more extensively, and will produce a superior quality of stone for fine construction.

In the eastern half of Logan county a large island of Corniferous limestone occurs, the center of which is covered with shales, but all around the edges small quarries have been opened for the purpose of obtaining stone both for building purposes and for lime. (a)

At the present time the only quarries of special importance that are located in this district are those which are situated a short distance to the northwest of Bellefontaine, and the material which they produce is used chiefly for rough work. Although capable of producing excellent building material, the more important stone structures in the neighborhood have been built of materials brought from a greater distance. The quarry operations are carried on in a quite primitive manner, and at present the lower strata in one quarry are inaccessible, since no means of



drainage have been supplied, and the quarry is filled with water to a depth of from 12 to 15 feet. The top layers of the stone are being extracted, although the lower layers are best suited for purposes of construction.

The quarry of Angel, Miller & Co., situated a half mile west of Bellefontaine, exhibits the following section:

Drift.....	feet..	5
Cellar stone.....	do...	10
Heavy hard stone.....	do...	5
Honey-combed porous stone.....	inches..	9
Heavy soft stone.....	feet..	5

Occasionally some lime is burned at this quarry, although its amount is small and its quality inferior.

The material that is at present produced by these quarries is a typical dolomite, and in microscopic structure consists of a perfect mass of sharply defined large rhombohedral crystals of dolomite cemented together by a mass of minute little crystals of the same form and composition. In many places the crystals are only attached at their corners, leaving angular interspaces, and this accounts for the avidity with which water is absorbed by this stone. The fossiliferous character, if any originally existed, has been entirely obliterated. In color it is light gray, and it works easily and safely. Its microscopic structure is illustrated upon the plate at the end of the chapter.

The first quarry in Marion county was opened in 1825 in what is known as the Marion limestone. Ten acres only are considered as belonging to the quarry. It is situated in the southeastern part of the town of Marion, and is the farthest south of any quarry in the neighborhood producing good building stone. A gray stone occurs about 12 or 14 feet below the surface, and is probably underlaid by blue-stone, but as the gray is considered the best the lower courses have not been opened.

Other quarries are located in the northeastern part of the town which extract material for building and quicklime. The largest quarries are, however, operated on the Columbus and Toledo railroad, one mile north of Marion. The stone is considered very strong and durable. The average thickness of the rocks extracted is not more than 8 inches, although blocks 12 and even 15 inches thick are sometimes obtained. There is no difficulty in extracting blocks of any required dimensions in the bed for all ordinary purposes of construction. The stone is easily quarried, being lifted with bars and broken with sledges, no blasting operations being necessary except to make an opening in the floor of the quarry for deeper workings.

The material is chiefly used for foundations and bridge work, and was largely employed in the construction of the depots and shops of the Columbus and Hocking Valley railroad. It is commonly called blue limestone, although the color differs at different horizons, and the layers also vary in texture and hardness, each layer, however, being homogeneous. The stone is usually quite fine in grain and rather hard. The following may be regarded as a typical section representing this and all other quarries in the neighborhood of Marion:

	Feet.
Soil.....	1 to 4
Weathered rock.....	1 to 4
Blue-stone.....	1 to 6
Gray-stone.....	4
Blue-stone.....	

The overlying blue-stone is found in blocks from the exterior of which a gray color penetrates to a variable depth from the natural joints. It is liable to contain flinty nodules, from which the underlying gray-stone is almost entirely free. The blue-stone in the bottom of the quarry is free from this gray covering; but the intermediate stone, which is all gray, is considered the best material.

In these quarries the gray-stone is found near the top, but in the other quarries reported from this township, being about  $1\frac{1}{2}$  miles to the southeast of these, and in the direction of the dip of the strata, this gray layer is not struck until a depth of from 12 to 16 feet from the surface is obtained. A very large amount of the cap-rock has been used for macadamizing streets and for ballast on the Columbus and Toledo railroad. The quarries in this township furnish the greater part of the stone used in the northern part of Union county and in quite a large portion of Hardin county.

The material quarried at Marion is dolomite, containing some calcite. When microscopically examined it is found to consist of a multitude of perfect little rhombohedral crystals, each one of which contains a little black bituminous substance accumulated in its center, and all are cemented together by the calcite, which, although crystalline, does not assume a definite outline. The rock, when treated with cold and dilute acid, effervesces for a while, and the residue when examined is found to consist of a multitude of perfect and beautiful little rhombohedrons. The Marion stone has been selected for representation in the plate of microscopic sections, and some further remarks concerning its chemical composition and structure will be found in the general remarks that close this chapter.

At Owen's station, in the southern part of the county, there is a quarry in the Corniferous limestone from which over 9,000 tons of lime and broken stone were shipped during the census year.

Six miles northeast of Marion, in the township of Grand Rapids, the same limestone is worked quite extensively. A ridge occurs at this point in which a number of quarries are located.

Crawford county is well supplied with building material. The limestones are quite well adapted for construction of foundations, but they are not at the present time extensively quarried owing to a number of causes. There are

no great demands for stone in this agricultural region, and the home resources are thrown into competition with the Berea grit, which is quite extensively quarried at Leesville, in the southeastern part of the county. In Holmes township, about 6 miles northwest of Bucyrus, and near the Ohio Central railroad, three quarries are at present worked in the Corniferous limestone. The material has much the appearance of the Marion limestone, but, while it may be of the same quality, the courses are generally thinner and not so well bedded.

In Lykins township the same limestone is also quarried to some extent. The material from all these quarries has been used for bridge building and for foundations, but it is more and more displaced by the Leesville sandstone, especially for bridge-building purposes.

A large quantity of quicklime has been produced here which has been shipped from Nevada, in Wyandot county, by the Pittsburgh, Fort Wayne, and Chicago railroad.

For building purposes the limestone which is quarried from the Corniferous formation at Bloomville, Seneca county, has a higher reputation than the Helderberg limestones, and indeed it is said that these quarries produce one of the best limestones in northwestern Ohio. The material has been quite extensively used in Tiffin for many years for trimmings and stone fronts, and also for general building purposes in Mansfield and in the surrounding country. Good material for flagging, bridges, and foundations is quarried, and a slab 25 feet square might be obtained. It has already displaced in a measure at Mansfield the sandstones which are quarried in that vicinity.

The specimens sent to the museum are of an attractive gray color and are highly fossiliferous. Some fossils have apparently been entirely removed at some period and their places subsequently supplied with a clear crystalline calcite, and some of the fossil forms are therefore strikingly apparent upon polishing the surface of the stone.

Under the microscope the stone is found to consist of a grand aggregate of fossil fragments, among which here and there the rhombohedron crystals of dolomite are developed in much perfection. The number of these rhombohedral crystals is, as usual, proportionate to the amount of magnesia in the rock, which in this case is about 16 per cent.

The limestone industry in and about Sandusky is one of the most extensive in the state. This is partly due to the abundant and excellent supply of building stone furnished by the Corniferous strata of this region, and partly to the facilities for transportation by water and by rail. The city of Sandusky is founded upon a ledge of limestone, and excavation of any kind necessitates quarrying operations. In early days the stone thus extracted was the cheapest building material accessible, and came to be used very extensively. As a result the use of stone is more general there than in any other Ohio town.

At Sandusky the upper layers of the Corniferous formation are composed of a blue limestone of a thickness from 20 to 25 feet. This is underlaid by the white Sandusky limestone, which is found in thicker courses, cuts easier, and is capable of making a better lime; but at Sandusky this stratum, which is also from 20 to 25 feet in thickness, lies beneath the level of the lake, and is not readily accessible. The dip of the strata is, however, away from the water, and consequently this layer of white limestone is brought to the surface at Marblehead and on Kelley's island, as is shown in a number of quarries. The largest quarries are situated at these points. Sandusky itself, owing to the circumstances mentioned, possesses quite a large number of quarries, and the city itself constitutes in fact a great limestone quarry covered with but a very shallow layer of soil or earth. These city quarries have been worked very largely for home and foreign supply, not less than 12 acres having been excavated to a depth of 8 feet. The Sandusky blue limestone is found in layers of convenient thickness, and the range work furnished by it presents an attractive appearance. The courses vary between 4 and 10 inches in thickness, and the material is used largely for flaggings, although not very well adapted for this purpose. It is laid in slabs from 4 to 8 feet square, which are not very smooth or regular until they become polished by wear, and then they are dangerously smooth. For construction purposes the stone has proven very durable, and the best foundations can be secured at small expense if made from this stone. It is also used for macadamizing the streets, and recently it has been found that a foundation of the Sandusky blue limestone can be advantageously overlaid by a thin coat of the white limestone which binds and cements the road-bed.

All of the quarries which in the tables are indicated as existing in the corporate limits of Sandusky are essentially one, as they produce the same material, and only in a single case has a quarry been sunk to the level of the underlying white limestone. About one hundred and eighty houses in the city have been constructed of this stone. The specimens sent to the National Museum from various quarries are identical in their minute structures. They are bluish-gray in color, compact, and present a fine appearance, however dressed. Although they effervesce rapidly in acid, they are quite magnesian, and under the microscope they are seen to consist of fossil fragments, among which a multitude of little rhombohedral crystals are developed. In the center of each one of these rhombohedrons is a black spot, which, upon close examination, is found to consist of pyrites. Sometimes, instead of a single spot, there is a large number of dust-like particles, which give to the stone a very marked and characteristic appearance. These are so numerous that it can scarcely be doubted that they impart the characteristic color to the stone. That they are situated, however, in the exact center of compact crystalline material cannot but have an influence in protecting them from disintegration, and there is no evidence that the presence of this ingredient has proved deleterious to the stone.

The white underlying limestone is what is called a cutting stone, and can be raised in blocks as large as can be handled. It is more highly fossiliferous to the unaided eye than the blue limestone, but under a microscope it is less so, and there is a much larger number of the rhombohedral crystals which correspond to its more magnesian character.

At point Marblehead the limestone quarries are all located in a terrace lying a few rods from the beach, where the thickness of the formation quarried is from 15 to 25 feet. Already 20 acres, as estimated, have been excavated to this depth.

These quarries are among the most famous of northern Ohio, and their location directly on the shores of lake Erie, and the heavy stones that some of them produce, have led to very large use of the stone, especially in the government works along the line of the great lakes. Latterly they are losing their place as building stones to some extent, but the production of lime has increased. Some quarries have been worked for at least fifty years. In these quarries the lower 6 or 8 feet are cemented into one solid sheet from which the large dimension stones for which the location is famous are extracted. It is from these quarries that a large part of the heavy stone used in the Sault Ste. Marie canal, in the northern light-houses, and in other government works has been derived. Many of the most important public and private structures in the region of the great lake were built of the Marblehead stone. The Detroit and the Cleveland water-works, the light-houses at Spectacle reef, Marblehead (built over fifty years ago), and Stanard's Rock, lake Superior, were all wholly or partly built of this material. It is particularly valuable in situations where it is exposed to the action of water or frost, as is shown by the condition of the old locks of the Sault Ste. Marie Falls canal and the light-houses in exposed situations.

The material from these quarries, like that at Sandusky, is a magnesian limestone, which contains beautifully-preserved fossils; the centers of the little rhombohedral crystals that characterize all of the Sandusky limestone are free from the grains of pyrites which characterize the blue Sandusky layers, and the difference in the color of the two stones is to be attributed to this circumstance.

The following analysis, made by Mr. J. Lang Cassels, represents the composition of the limestone from these quarries:

	Per cent.
Calcium carbonate .....	83.20
Magnesian carbonate.....	15.83
Silica .....	0.15
Organic matter.....	0.02
Moisture .....	0.80
Total .....	100.00

The proprietors claim that they could easily extract a block of stone equal in size to the Egyptian obelisk recently introduced into this country, its extraction being simply a matter of expense.

The block-stone proves to be a source of excellent lime, which has long been used, but which of late has been more abundantly produced. All of the waste material is devoted to this purpose, and nothing remains in the quarries except flint nodules. The modern kilns of the best construction are attached to some of the quarries, and 300 or 400 barrels per day are turned out from one single quarry. Part of the thin stone goes to lake Superior for furnace flux, where it is highly esteemed, and a large trade in the lime has been built up at Duluth and in the northwest, and the best stone of the quarries is now being burned. Much of the stone is shipped to other points to be burned, and all along the lakes are kilns which are supplied from Marblehead and Kelley's island. The Michigan Insane Hospital building at Pontiac and the government breakwaters at Erie were constructed of the Sandusky stone.

At White House, in Lucas county, the same lower beds of the Corniferous are worked, and this is the only quarry which is operated to any extent on the Toledo, Wabash, and Western railroad between Toledo and Wabash. Some of the material is shipped to Toledo, as there is a demand for it in the winter, when, on account of the ice, the stone quarried near Sandusky cannot be shipped to Toledo by water.

Near Defiance there is some stone quarried from the beds on the Miami river, and the same is true at Antwerp. The quarry at White House was not extensively worked until 1879, when the railroad track was laid into it. The cap-rock has been used for ballast on the railroad, so that the stripping is accomplished without expense.

The weathered rock which is used for ballast is from 2 to 8 feet in depth, and this is underlaid by 6 feet of gray-stone in courses of from 6 to 10 inches in thickness, 6 feet of blue-stone in courses from 6 to 18 inches in thickness, and one course of gray-stone 1 foot 10 inches in thickness. The bottom course is nearly uniform in thickness and is used for heavy bridge work. The blue-stone is not of a decided blue color, like that of the Upper Corniferous at Sandusky, but is a kind of grayish-blue.

Napoleon and Defiance, Ohio, and Fort Wayne, Indiana, furnish the principal markets for this stone.

In the townships along the Muskingum the sandstone, which is situated below the coal, affords an excellent building stone and is extensively quarried. The Waverly sandstone also occurs in the western portion of the county. The limestones which also occur in the county are, upon the whole, of rather inferior quality for purposes of construction, and would scarcely be worked if the lime which can be made from them was not of good quality and demanded for construction in the neighborhood.

**SUB-CARBONIFEROUS.**—A quarry situated at Newtonville, about 8 miles west from Zanesville, is the only one in Ohio from which limestones of sub-Carboniferous age are raised for building purposes. There are several large quarries in other exposures of this same horizon in southern Ohio that are worked exclusively for furnace flux and for lime-burning. The Newtonville stone is a beautiful material, very fine grained, quite even in color, and of great strength. It is very compact, highly fossiliferous, of light gray color, and has thus far shown no ill effects from exposure to the weather. The Muskingum County court-house, at Zanesville, one of the finest in the state, is built from this stone, and it has also been much used for caps, sills, columns, etc., and although the production at present is small, it may at any time be increased with a demand for the material; but at the present time most of the product is burned. A thickness of about 10 feet of stone is quarried, that being the depth to which natural drainage extends. Several feet more of the best of the stone lie below this level, and the thickness of the layers increases with the depth; upon the top there are only very thin beds, while at a depth of 10 feet the beds are 16 or 18 inches in thickness. The material is nearly a pure carbonate of lime, containing only traces of iron and magnesia. In its microscopic structure it appears to be quite highly fossiliferous and very compact, containing only small traces of iron pyrites, the oxidation of which imparts the faint yellow color which the stone generally possesses.

**CARBONIFEROUS.**—A quarter of a mile southwest of Zanesville, near the Muskingum river, a quarry has been opened in the limestone of the Lower Coal Measures, from which some material has been extracted which has been used chiefly for caps, sills, and top courses of foundations. The main product of this quarry is burned into lime. It is not used for the ruder purposes of construction, as it is too expensive. The ledge from which this stone is taken is a solid mass of a bluish color, and about 3 feet in thickness. The stripping which overlies the 3 feet of stone is 25 feet thick. The material is a compact, earthy limestone of a very dark color, containing considerable protoxide of iron and very little magnesia. It is very highly fossiliferous and difficult to work, and is called by the stone-cutters hard and plucky.

The outcrops of this stone are found abundantly in the neighborhood of Zanesville, and the material is quite extensively used for macadamizing streets. The national road for some distance west of Zanesville is constructed of it.

There is quite a large number of quarries situated in the outcrops of Carboniferous limestone in southeastern Ohio, the products from which are used as fluxes and for burning, but the two quarries which have been mentioned in Muskingum county are the only ones which are of any consequence as producing materials of construction. The Carboniferous limestones of this area are hard to work and do not possess the highest requisites of a good building stone, but these quarries are capable at any time of producing material for building, and in fact does so under special circumstances. Although these quarries are worthy of consideration in connection with their ability to produce building stones, still the industry is so insignificant that it has not been considered important to tabulate the products of any of them.

To recapitulate: The line drawn nearly through the center of the state from Erie county on the north through Adams county on the south will form the boundary between the area to the east, in which the chief quarrying industry is devoted to the extraction of sandstones, and the western area, in which the only quarrying industry is devoted to the extraction of limestones.

The geological formations in the limestone area follow one another in a quite regular order, the oldest being situated in the southwestern corner, and the youngest in the eastern part of the state; and the character of the stone is entirely dependent upon this geological arrangement, as regards both the character and the quality of the material.

A considerable quantity of stone is extracted from the Cincinnati group, but, as already indicated, this is chiefly owing to the circumstance that the material is in the neighborhood of the large city of Cincinnati. In quality the material is surpassed by the stone from other formations. A narrow band of Clinton limestone surrounds the area of the Cincinnati group, but at the present time this formation furnishes no building stones.

The Niagara or Cliff formation, which succeeds, is one of the great building-stone formations of the state, and in numerous places most excellent and durable materials are obtained; but even the subdivisions of this group determine largely the character of the stones extracted. The lowest or the Dayton formation produces at all points a hard, compact, light stone, while the Springfield division produces a less compact, more easily worked stone, and the top beds are almost universally converted into quicklime.

The Helderberg or Water-lime rocks, which cover a large area, are almost without exception bituminous dolomites, but in character vary from dark to light and from compact to open or vesicular. The Carboniferous limestones are most extensively quarried in and about Sandusky, and furnish one of the finest materials obtained in the state, while all of the overlying formations are almost devoid of building-stone quarries. As regards composition, the stones from these various formations vary from almost typical limestones to almost typical dolomites, and there seem to be no rules which will enable one to decide upon the quality or durability of the stone from its composition. Experience also demonstrates that the composition, as regards the proportion of

lime and magnesia, does not determine the value of the stone as material for the production of quicklime. It would therefore appear that the value of the stone is more largely dependent upon its accessory constituents and its microscopic structure.

There is a progressive increase in the amount of magnesia from the Lower Silurian limestones to the Carboniferous. The Cincinnati limestones of the Lower Silurian contain from 1 to 5 per cent. of magnesian carbonate, while the Clinton limestones of the Upper Silurian contain on an average about 12 per cent. The Dayton limestone of the Niagara period contains about the same amount, while the upper divisions of the Niagara and the Helderberg formations are made up mainly of nearly typical dolomites. As regards composition the next following Carboniferous limestones are very variable. At Bellefontaine the stone is a dolomite, and at Columbus it is as good a limestone, containing on an average 93 to 95 per cent. of carbonate of lime, and the Hocking Valley furnaces are largely using it for a flux.

In structure there is less diversity in the Ohio limestone than in those of some of the other states, since the oolitic and concretionary forms do not appear; but all other types are found, and therefore the greatest diversity exists in the ease with which stones may be worked. There are the open, porous varieties, and the varieties which once were open and porous, but which have been again partially consolidated by the filling of the pores; others in which the pores have been entirely filled; and other varieties in which large crystals have developed themselves in a ground mass, giving to the stone a porphyritic aspect. There are the compact fossiliferous stones and the compact non-fossiliferous stones. As regards colors, they vary from very light to very dark, but all possess the drab, gray, or yellowish tints which are characteristic of what are called limestones.

In microscopic structure the limestones of Ohio can all be classified according to certain types of structure which are found to be correlated with composition. It may be at first remarked that the microscope indicates that the stones are all highly crystalline. A crystal is a body which possesses a definite internal molecular structure, and if it is further assumed that the external crystalline form is a property of crystals, then many Ohio limestones are more crystalline in their structure than are the so-called highly-crystalline marbles; for in a great many cases the very well developed crystals with external planes are developed in the mass of the stone, and in other cases the stone is entirely composed of such crystals with the form characteristic of the species of the mineral which composes it. In no case has there been found in any Ohio limestone anything which could be called in any correct sense of the word uncrystalline; and, indeed, in the light of the microscopic study, any distinction which can uniformly distinguish a limestone from a dolomite is very difficult to find. The progressive increase in the amount of magnesia which is contained in stones is indicated in the microscopic structure by the development of little rhombohedral crystals the sections of which appear quite conspicuous with their sharply-defined edges.

## INDIANA.

[Compiled mainly from notes of Professor Orton.]

The rocks of the Cincinnati epoch of the Lower Silurian period occupy a small area in the southeastern part of the state, but no quarry rock is developed in this formation. Its western limit is roughly defined by a line drawn from Winchester, Randolph county, to Madison, Jefferson county.

The rocks of the Niagara epoch of the Upper Silurian period occupy a more extensive territory north and west of this line. This formation furnishes stone for foundations, underpinnings, and bridge work in nearly every county which it occupies. In a few localities the stone is suitable for the better architectural purposes, and in some places an excellent flag-stone is produced. The Helderberg formation has not been identified in Indiana. The approximate northern and western limits of the Upper Silurian formation are marked by a line drawn from Fort Wayne to Logansport, and thence to the eastern extremity of Clark county.

The Devonian formation occupies a narrow belt to the west of the Silurian. It has a meager development, its entire thickness being only about 200 feet, and it furnishes little building stone. The line between this and the sub-Carboniferous formation may be roughly drawn from the northwest corner of Benton county to the northwest corner of Clinton county, and thence to the southern extremity of Clark county.

As to production of stone, the sub-Carboniferous is the most important formation in the state. It furnishes the famous "Bedford limestone," and also some valuable sandstones, which are, however, mostly noted for their adaptability to the manufacture of grindstones and whetstones.

The Coal Measures occupy the southwestern part of the state, and the dividing line between this and the sub-Carboniferous formation is nearly that from the southern extremity of Perry county to a point about 5 miles southwest of the northeast corner of Warren county, and from there west to the state line.

The coarse sandstone, commonly known as the "conglomerate", at the base of this formation is found in a region on all sides of which for many miles little sandstone suitable for heavy masonry is available, and also near large districts entirely destitute of building stones; but as yet no large quarry industries have been developed in this formation.

The northern portion of the state beyond the line drawn across it through Fort Wayne and Monticello is deeply covered with drift material. The granitic boulders found quite abundantly on the surface in some localities

furnish the only local supplies of stone in this extensive district. It is in this region that a considerable market is found for the sandstones quarried at Stony Point, Michigan, and Berea and Amherst, Ohio, and for the limestone quarried in the Bedford district in southern Indiana, and in the Joliet district of Illinois.

#### LIMESTONE.

The localities north of Indianapolis where limestone is quarried for building stone, with a few exceptions, deserve but a passing notice. At Wabash quite an important flagging stone is obtained at the quarries of Messrs. Bridges & Seot, Hubbard & Smith, Philip Hipskin, and William J. Ford; important because it is the best stone for sidewalk pavements to be obtained for many miles around. It occurs in layers from 1 inch to 7 inches in thickness, those from 2 to 5 inches thick being most commonly used for flagging, and the heavier courses for foundations and bridge work. The joints run quite regularly, and occur far enough apart to allow the largest required slabs to be obtained. The surface of the natural slabs is, however, rather too rough to allow the stone to be classed with the best of flag-stones. The quarry of Messrs. Moellering & Paul is in a different stratum of the Niagara limestone; the beds vary in thickness from 3 to 15 inches, and the stone is shipped to Fort Wayne, where it is used for foundations and underpinnings. The quarry of Messrs. Little & Shoemaker is in a thin, irregularly-bedded limestone, commonly called "shell-rock". It is easily worked, and is cut through by the Wabash and Pacific railroad, which furnishes direct transportation for the quarry product to Fort Wayne, where such stone is in demand for ordinary foundations.

The quarries in Adams, Wells, Howard, Grant, Blackford, and Delaware counties furnish stone for light bridge work and for foundations.

The most valuable deposits of limestone that have been quarried for building purposes in northern Indiana are in Cass and Madison counties.

The quarries of Messrs. J. E. Burns and August Gleitz are located about 3 miles west of Logansport, Cass county, in the south bank of the Wabash river, and in a stratum of compact, though easily-worked, uniformly-colored limestone, in layers from 4 inches to 4 feet thick. These quarries have furnished the stone for the superstructures of some fine church buildings and for quite a large number of dwellings, stores, shops, etc., in Logansport. This stone presents a very pleasant appearance in a building when dressed rock-face. The stone from the quarry of Messrs. Lux & Lux, at Logansport, is used for foundations.

The Anderson, Madison county, quarries are located in an evenly-bedded limestone which works quite well under the chisel. This stone lies in beds from 4 to 12 inches in thickness, and is used in the town of Anderson for flagging, foundations, caps, sills, etc. It is rather beautiful and quite durable.

There is a number of localities in northern Indiana, south of the drift-covered region, where limestone is quarried for the manufacture of quicklime. A large amount of lime of excellent quality is burned annually at Huntington, and considerable amounts are burned at Peru and Delphi.

In the Upper Silurian or Niagara formation there are quarries of considerable importance in the southern part of the state, but by far the most valuable building stone of the state is obtained from a stratum of limestone in the sub-Carboniferous formation. This limestone is supposed to belong in the geological scale to the Saint Louis group of the sub-Carboniferous period. It occurs in massive beds of almost pure limestone, varying in different localities from an ordinary gray to an almost pure white color, and having a granular or oolitic structure. It is known by Indiana geologists as the "oolitic limestone", and is commonly known in the trade as Bedford stone and Indiana stone. A piece of the stone dressed in the shape of a flat bar rings like iron when struck, and it is very elastic, strong, and durable. It does not take a fine polish, but its adaptability to carved work is well shown in the elaborate carving in the mansion of Mr. William K. Vanderbilt, built of this material, on Fifth avenue, New York city.

In the Greencastle quarries the stone has a light gray or drab color, and is susceptible of receiving quite a high polish. This stone differs considerably from the sub-Carboniferous limestone in the Ellettsville, Stinesville, Bedford, and Salem quarries; it is harder, less granular, takes a higher polish, and occurs in thinner beds. This stone is used for the construction of cellar walls, for bridge work, blast-furnace flux, and lime-burning.

The quarries at Okalla, Putnam county, furnish material for bridge construction and for lime. The stone differs little from that quarried at Greencastle. At the Putnamville quarry the stone is heavily bedded, highly siliceous, quite hard, of a light gray color, and receives but a slight polish. It has a very compact, fine, granular structure. This stone is employed in all kinds of building, principally in the cities of La Fayette, Terre Haute, and Crawfordsville.

The quarries at Longwood, Fayette county, furnish stone for bridge work, cellar walls, steps, and some flagging. The material finds its principal markets at Connersville and Rushville. The specimens forwarded to the National Museum represent a buff variety and a drab mottled with buff. Both varieties take a medium polish, and from the latter tombstones have been made. The quarries near Laurel, in Fayette and Franklin counties, furnish stone for foundations, bridge work, and flagging to the country along the line of railroad from Cincinnati, Ohio, to Muncie, Indiana. This stone has quite a beautiful drab color, a compact structure, and is strong and durable. It works well under the chisel and takes a medium polish.



The New Point, Greensburg, and Saint Paul quarries, in Decatur and Shelby counties, furnish stone for general purposes of construction and for flagging. The material finds its principal markets at Cincinnati, Ohio, and at Indianapolis, Terre Haute, and La Fayette, Indiana. A section at New Point quarry exhibits 2½ feet of drift; 3 feet of thinly-bedded rock, used for rubble and lime; and below this 4 feet of cutting stone. It is estimated that the value of the lime sold annually from this quarry is about one-third of that of its entire product.

The specimen forwarded to represent the material from this quarry contains numerous crystals of pyrites, varying in size from the smallest that can be seen with the naked eye up to half an inch in diameter. The stone works well, but does not take a good polish.

At the Greensburg quarry the stone is more crystalline and is susceptible of being quite highly polished. It is rather hard and slightly plucky. It is used for all building purposes, and the thinly-bedded stone in the upper portion of the quarry is used to some extent for flagging and for railroad ballast. A section of the quarry exhibits 6 feet of drift material, 7 feet of thinly-bedded stone, and 9 feet of cutting stone.

At the Saint Paul quarries the stone is quite highly crystalline, works well, and takes a medium polish. It is used for all building purposes and for flagging. Mr. J. L. Scanlan manufactures lime, and it is estimated that the value of lime burned is about two-thirds that of the entire product of his quarry. The material which is burned is the thinly-bedded rock occurring above the cutting stone. A section of the quarry shows 4 feet of drift, 10 feet of lime-rock, and 10 feet of cutting stone.

A section of Mr. W. W. Lowe's quarry shows 1 foot of drift, 5 feet of thin stone, and 20 feet of cutting stone.

The quarry of Mr. G. W. McNeely, 2 miles west of Saint Paul and in Shelby county, is worked in 6 feet of thinly-bedded stone, and furnishes foundation stone and flagging to the neighborhood. The stone from these quarries may be equal in beauty and durability and even superior in strength to the oolitic limestone, but it is not so extensively employed, especially for the better kinds of architectural uses, because it is harder to quarry and to dress, and cannot be obtained so readily in large-sized blocks. It has been chiefly used for foundations and bridge abutments, and the thin, evenly-bedded layers are extensively used for sidewalk paving.

The oolitic limestone is quite extensively quarried in Monroe county, and the Ellettsville stone is used for all building purposes in Chicago, Saint Louis, Indianapolis, and also in many of the smaller cities and towns in Indiana and Illinois. The following are some of the buildings in which examples of Ellettsville stone may be seen: Indiana state-house, Marion County court-house, and the Vance block, at Indianapolis; the custom-house and post-office, Evansville; Knox County court-house, Vincennes; Dearborn County court-house, Lawrenceburg; Posey County court-house, Mount Vernon; Clark County court-house, Jeffersonville; Bartholomew County court-house, Columbus; Johnson County court-house, Franklin; Asbury university, Greencastle; Wabash college, Crawfordsville—all in Indiana; and the state capitol, Springfield, Illinois.

A section of the quarry of Messrs. John Mathews & Sons shows first 3 feet of clay, then 7 feet of worthless rock, called "bastard" limestone, and, below this, 18 feet of limestone in one bed, which has, however, several "cone-in-cone" seams. This stratum has not been worked to the bottom in this quarry.

There are 2 feet of clay and 6 feet of bastard limestone over the building stone in the quarry of Messrs. Perry Brothers. The bed of building stone has been worked to a depth of 34 feet, divided into five layers by cone-in-cone seams. The stone in the top and bottom layers, respectively 8 and 6 feet thick, is quite hard, and is used in the construction of bridges. The intervening 20 feet consist of two layers, each 5 feet thick, and one layer at the bottom 10 feet thick. All the stone in these three layers is easily worked.

The disintegration of the fossil fragments, mostly coral, of which this stone is largely made up, has gone to such an extent in the Ellettsville stone that the fragments are very small, and the interstices between them have been so completely filled as to give the stone quite a compact structure. The representative specimen from the Stinesville quarries shows a much coarser and a more open structure, the fossil fragments being much larger and the interstices between them being less perfectly filled; however, the material is about as widely distributed, though somewhat less extensively, and is used for similar purposes.

The last-mentioned quarries are located near each other. The one at the lowest level has 28 feet of limestone exposed, with a small honey-comb seam about 6 feet from the top. The two other quarries have about 30 feet of limestone exposed, with the honey-comb seam coming in at a depth of about 12 feet.

The entire section of the Saint Louis group is exposed at the quarry of Mr. B. Schweitzer, in Owen county, but the oolitic limestone is not well developed here. About 70 feet of limestone, varying, at different heights, in color, texture, and composition, are worked; and from 4 to 10 feet of the lower portion of this is a white limestone, which is burned. The lime product represents about one-fourth of the entire quarry product in value.

The building stone occurs in layers from 2 to 14 inches in thickness, being mostly a very fine grained and compact material, with a conchoidal fracture. It is not suitable for cutting; but, being evenly bedded, is well adapted for the construction of foundations, for which the blocks are easily squared up. The stone finds its principal markets at Indianapolis, Terre Haute, Vincennes, and Evansville, Indiana.

Bedford, Lawrence county, furnishes the "Indiana limestone", famous over a large portion of our country, known as "Bedford stone" in some markets. As is shown in the tables, most of the Bedford quarries now worked have been quite recently opened. The stone has only within a few years come into extensive use, though it has been quarried and used in a small way for twenty-five or more years. At the present time it is one of the stones most extensively employed for architectural purposes in the city of Chicago. The fossil fragments of which the stone is composed are quite uniform in size, of about that of an ordinary grain of sand, and the interstices between them are well filled, giving a uniform texture and firm structure. The appearance of the stone, when dressed in any manner applicable to limestones, is good. The qualities of beauty, strength, durability, and cheapness due to accessibility and ease of working possessed by the Bedford stone, tend to secure for it a very prominent place among the building stones of our country. The following are some of the buildings in which Bedford stone was used: Residences of Mr. W. H. Vanderbilt, Mr. I. Sherwood, and Mr. Cornelius J. Vanderbilt, Fifth avenue; residence of Mr. William H. De Forest, Fifty-seventh street; the Smith building, Cortland street; Appleby flats, corner Seventh avenue and Fifty-eighth street; Bridge building, Fourteenth street; flats, Eighty-fourth street and Eleventh avenue; and rectory, Fifty-first street—all in New York city; Cotton Exchange building, New Orleans, Louisiana; new city hall, Chicago; state capitol, Springfield; McLean County court-house, Bloomington; Peoria County court-house, Peoria; and county court-house, Olney—all in Illinois; new state-house and United States custom-house, Indianapolis; Grant County court-house, Marion; Lawrence County court-house, Bedford; county court-house, Shoals; Floyd County court-house, New Albany; Music hall, New Albany; Posey County court-house, Mount Vernon; United States custom-house and approaches, Evansville—all in Indiana; and United States custom-house and Jefferson County court-house, Louisville, Kentucky. In Louisville, Chicago, Saint Louis, Evansville, and Indianapolis there are scores of buildings the fronts of which are built of Bedford stone.

At some of the quarries there are from 4 to 5 feet of worthless rock on top; below this the solid bed of oolitic limestone has been worked to a depth of 40 feet, and the bottom of the bed is not yet reached. The amount of stripping varies in different localities. In some places there are but a few feet of clay on top of the oolitic limestone, while in other places the stripping consists of 12 or more feet of bastard limestone.

At the Lawrenceburg quarry, in the southeastern part of Lawrence county, and at the Fort Ritner quarry, near the line between Lawrence and Jackson counties, the oolitic limestone has not been so extensively quarried as at the Bedford quarries; the material, however, is of good quality. At Lawrenceburg the oolitic limestone has been worked to a depth of but 14 feet. From this quarry the material goes principally to Cincinnati and to Saint Louis.

At Fort Ritner only 10 feet of the limestone have been worked. The material was used in the construction of the court-house at Brownstown and the cathedral at Vincennes, Indiana.

The quarries in Jennings county are in the Niagara limestone of the Upper Silurian period, and the stone produced is quite like that from the same formation in Decatur county, which has already been described. Sections in these quarries show from 3 to 5 feet of drift material, and below this from 8 to 30 feet of quarry stone in evenly-bedded layers from 2 to 36 inches in thickness. The thinly-bedded layers are used quite extensively at Indianapolis and other cities for paving sidewalks. With these stones, when used for sidewalk paving and in rough masonry, nothing is necessary in the way of dressing beyond breaking the blocks into rectangular shape. The heavier layers are used extensively for the construction of foundations and bridge abutments, for which purpose this stone is well adapted on account of its strength, durability, and cheapness, due to the fact that little dressing is necessary for this kind of work on account of the evenness of the layers and the smoothness of the bed surfaces.

The specimen from the North Vernon quarries has a dark drab color, and that from the Oakdale quarry a light drab or gray color. The former represents what is locally known as the North Vernon "blue limestone", which was used in the construction of the Ohio River bridge of the Cincinnati Southern railroad. The strata occur near the surface of quite an extensive area along the lines of the Ohio and Mississippi railroad and its Louisville branch and the Jeffersonville, Madison, and Indianapolis railroad.

The quarries worked at Osgood, Ripley county, are also in the Niagara limestone, and the principal use made of the product is for flagging and curb stones. The material finds its principal markets at Cincinnati, and at Covington, Kentucky. At these quarries there are from 2½ to 5 feet of drift on top, and below this from 10 to 12 feet of quarry rock. The representative specimens of these stones forwarded to the National Museum contain a considerable amount of pyrites in the crystalline form. The stone is less applicable for cut work than for sidewalk paving, curb stones, foundations, etc.

Near Salem, in Washington county, the oolitic limestone has quite a valuable development. Under about 5 feet of cap-rock a solid stratum of limestone 30 feet in thickness occurs. Six feet of the lower portion of this, however, is not used on account of its being too hard. The remainder of the stratum is quarried for all kinds of building purposes, and the material finds its principal markets at Louisville, Kentucky, and New Albany, Indiana.

Samples of this material may be seen in the court-house at New Albany, and in the Galt house and city hall at Louisville, Kentucky. In color, texture, and ease of working this stone differs little from that quarried at Bedford.

At the New Albany quarries, in Floyd county, the oolitic limestone is somewhat harder and less valuable for architectural purposes. It is principally used for foundations and street pavements at New Albany. Only 9 feet of limestone is quarried, and the cap-rock is about 25 feet in depth—16 feet of clay and 9 feet of worthless sand-rock. This depth of cap-rock of course increases the expense of quarrying to a considerable degree, but the quarries can be worked with profit so far as the material may be in demand at the New Albany market for the above-specified purposes, no other material so suitable for the same uses being so near at hand.

#### ILLINOIS.

BY PROFESSOR ALLAN D. CONOVER, *Special Agent.*

The state of Illinois embraces rocks representing most of the epochs of the Silurian, Devonian, and Carboniferous ages, and including most of their varieties in texture. Over the greater part of its area these rocks have been but little disturbed, and occur with beds approximately horizontal or inclined at a small angle to the horizon. In a few localities, however, very considerable disturbances of the normal relation of the strata have taken place, usually within rather restricted areas, and have been accompanied in some places by marked changes in the physical characteristics of the rocks, which have affected very considerably their value as building material.

The surface of the state is almost everywhere covered by a variable depth (at places but a few feet, at others much over 100 and possibly over 200 feet) of the looser deposits of the Tertiary and the Quaternary ages. Owing perhaps partly to the nature of its rock formation, but most largely in all probability to these subsequent deposits, a very large portion of the state presents a very level or slightly-undulating prairie surface, within the limits of which are but few rock exposures. This is true of the whole central and eastern part of the state, the larger portion of its territory.

Skirting this great area on all sides except the east is a country of very different character, though the change is gradual—a valley country with very marked water-courses, which cut through the beds of clay and sand to and into the rock formations below. Throughout the greater part of this area the rocks immediately underlying are Silurian, Devonian, or sub-Carboniferous, all of which furnish excellent building materials, and but few localities of considerable area are found where at least a fair building material cannot be easily obtained.

#### SILURIAN.

**LOWER MAGNESIAN.**—The oldest of the Silurian rocks occurring in the state, the Lower Magnesian or Calciferous, is found in two small areas in the central northern part of the state, one lying principally in Ogle county and the other mostly in La Salle county. Its beds furnish a dolomitic limestone, utilized in the manufacture of cement, but is only fitted for the most ordinary of building purposes, and is nowhere systematically quarried.

**SAINT PETER SANDSTONE.**—The Saint Peter sandstone, occurring closely associated with the Lower Magnesian limestone in these localities, is a coarse-grained sandstone of various shades of dark-yellow or buff to reddish-brown, its grains not often sufficiently cemented to form a good building rock. In a few places in Lee county it is hard enough to quarry, and small quantities of it have been and are yet occasionally used. In La Salle county the lower 4 feet of the bed furnish an excellent and durable rough building material, which was formerly considerably used for heavy masonry, but is now very little quarried.

**TRENTON GROUP.**—In its northern area the Trenton group has two very distinctly marked subdivisions—the Trenton limestone and the Galena limestone.

The Trenton limestone in this southward extension from its southwestern Wisconsin area presents here very similar characteristics. It is nearly everywhere a rather thinly-bedded, close-textured, often semi-crystalline, hard, gray or light drab-colored rock, easily blocked into quite square and regular shapes, and furnishing a very excellent and durable, occasionally somewhat ornamental, building material.

It is found and quarried in small amounts in numerous places along the valley of Fever river, in Jo Daviess county, and there furnishes a good ordinary building stone only. In the eastern part of Stephenson county it is quarried in a few places to a slight extent, but is everywhere so deeply covered by clay and shales as to render quarrying it very expensive, while farther east, in Winnebago county, it occurs in numerous places, and furnishes a good ordinary building stone, easily quarried out and shaped. In this locality some of the dark blue and drab colored beds fade very rapidly upon exposure, finally reaching to a light buff color, as in the same beds in Wisconsin, near by.

In western Boone county these beds furnish the only building stone of value obtainable within the county, and are extensively quarried in the vicinity of Beaver creek, where they furnish more than usually heavy beds of a rather rough but durable stone well fitted for ordinary and heavy masonry.

In the vicinity of Mount Morris and of Polo, in Ogle county, these beds furnish an excellent and handsome building material which has been used quite largely in building at those places.

At Dixon the stone is thinly bedded, but has been largely quarried and used in the construction of the mills at that place.

To the south of these places throughout the remainder of this area, and also in the detached area closely adjoining it, the Trenton limestone beds are thin and irregular, and nowhere furnish building material of value. Wherever these beds occur quarries are so easily opened and worked that large numbers of them are found, each worked to a slight extent, but rarely furnishing regular employment at one spot for any considerable length of time to more than one or two men.

The upper subdivision of this group, the Galena limestone, occurs in these northern areas of the Trenton group in considerable thickness, in all between 200 and 300 feet. It everywhere presents very constant physical characteristics, and is a rather coarse and rough-textured stone, occurring in heavy, sometimes massive beds to over 5 feet in thickness; is rather hard to work, and hardens gradually upon exposure, forming a very excellent, durable material for all purposes except for fine ornamental work. Its color is a rather rich, warm buff tint, which deepens somewhat upon exposure, and when well worked it presents a very handsome appearance.

In Jo Daviess county there are numerous quarries, though none largely worked. Near Freeport, in Stephenson county, and within the city, are large quarries presenting solid walls of rock from 60 to 90 feet high, in which the upper beds are very thin, but those below are very massive. Large quantities of stone from these quarries have been used in this city, and numerous very handsome buildings and residences have been constructed of it. Near Rockford, in Winnebago county, it has also been quarried and very largely used in that city, particularly in the construction of residences. At Harlem and at Cherry Valley, in the same county, there are also large quarries, the stone from which is extensively used for heavy masonry, such as bridge work, for which it is found to be a most excellent material.

In Ogle county there are numerous outcrops, and the stone has been considerably used for heavy masonry, but there are no quarries largely developed. In Lee county the formation is finely exposed all along the Rock River valley, and has been quarried extensively at Big Springs and at Lee Centre, while at numerous points along the valley small quarries have been opened. At Dixon it has been considerably quarried, and was used with success for the piers of the large bridge erected there across Rock river. Where found in Whiteside county it presents the same characteristics, but is generally difficult to quarry because it is nearly everywhere deeply covered up.

The Trenton group is found within the state at four other points along the Mississippi river to the southward, but these subdivisions seem there to be less distinctly marked and have not been recognized and traced.

In Calhoun county the rocks of the Trenton group form the axis of an anticlinal running east and west, and are largely exposed on both the Mississippi River and the Illinois River sides of the county. On the Mississippi River side at about the middle of the county they form the base of the river bluffs, and rise southward till at Cap Au Gris, in Lincoln county, Missouri, they form the whole body of the bluff, exposing a total thickness of from 300 to 400 feet. At this point the lower beds of the series are quite heavily-bedded, compact, hard, grayish dolomitic limestone of great endurance, nearly, if not quite, equal in value to the limestone of the famous Grafton quarries in the Niagara limestone on the river, just below. These beds could be readily quarried and the stone lowered directly into barges in the river. A vast quantity of this stone can be readily and cheaply obtained.

On the Illinois River side of the county these rocks have numerous exposures, and are quarried in various places to a limited extent.

In Jersey county, where this axis crosses the Illinois river, the upper beds of this group are elevated above the river 40 or 50 feet. The rock is thinly-bedded, with shaly partings, and probably of little value as a building material.

In Monroe county the Trenton limestones are again found forming the base of the river bluff at Salt Lick point. They occur here in very heavy beds as thick as 6 and 7 feet, and are coarse-grained, quite even-textured, and of light color. From these same beds upon the Missouri side were obtained the great blocks for the columns of the Saint Louis court-house.

Farther south, in Alexander county, these rocks appear for the last time in this state and cross the Mississippi river in such a way as to form the rapids known as the Grand Chain. They rise on the Illinois side to a height of 75 feet or more and occur in very heavy beds—a light gray, fine, even-textured stone, some of the layers of which receive a high polish and would make an excellent and handsome ornamental stone. The same beds have been largely quarried at Cape Girardeau, in Missouri, just opposite, and the stone is known as the Cape Girardeau marble.

While in each of the last-named localities these beds are capable of furnishing quite cheaply vast quantities of building material, they have never, so far as I could learn, been worked to any extent.

**CINCINNATI GROUP.**—The rocks of the Cincinnati group, which immediately overlie those of the Trenton, consist mainly of more or less hardened clays, their composition in places varied by the addition of a considerable percentage of carbonate of lime. They furnish nowhere except in one locality any reliable building material, but are quarried in some places where their exceptional hardness renders them usable, and where other building stone is very scarce. In Boone county, where there is but one quarry (in Galena limestone, at Beaver creek) of limestone, a quarry has been opened in these shales just southeast of Belvidere, from which most of the building material for ordinary purposes used in that city has been obtained. In some buildings these stones have been exposed for nearly thirty years without showing much signs of injury. Very good flag-stones are also obtained from this quarry.